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MECHANICAL ENGINEERING

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VOLUME 68 NUMBER 3

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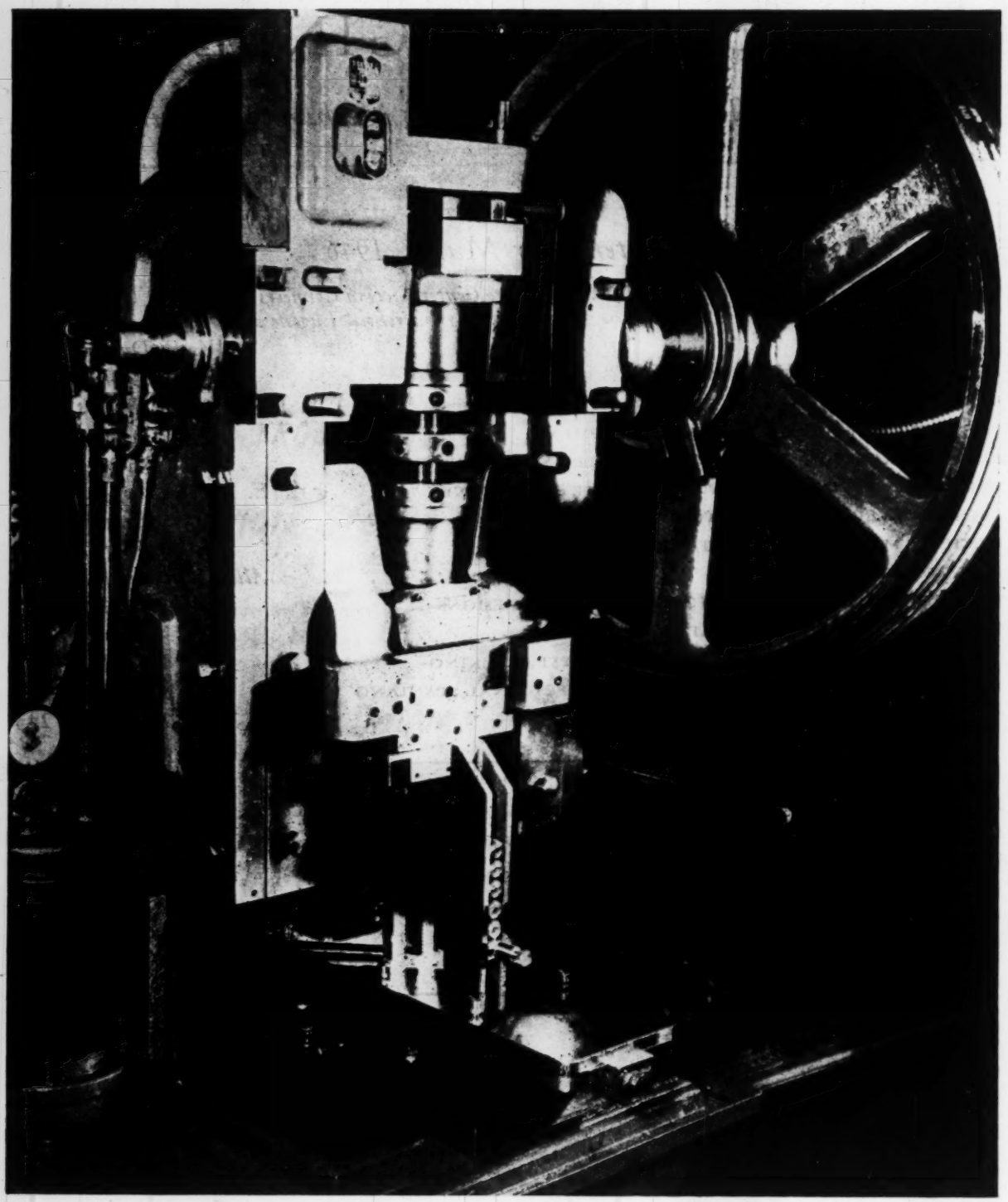

Something Old Into Something New

(Engineers at the Metal Manufacturing Division of The Electric Auto-Lite Company at Long Island City, N. Y., converted this punch press into a broaching machine to speed up the production of vitally needed 40-mm shell projectiles. The installation of the broaching blade will allow the broaching of 2400 wrench flats per hour . . . replacing a milling operation that allowed but 800 per hour.)

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MECHANICAL ENGINEERING

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1946

GEORGE A. STETSON, *Editor*

Release of Teachers

ONE way in which engineering schools in common with all colleges and universities suffered during the war was in the scattering of their faculties. Many teachers and research workers were taken from their regular posts for work on projects essential for the prosecution of the war. Others were attached to some branch of the Armed Forces because they had been reserve officers, because they enlisted, or because they were within the age groups subject to selective service.

With the ending of the war the problem of the schools has been to reassemble these scattered faculties and to add to them in order to handle the heavy teaching schedules that are the result of excessive enrollments. It is gratifying, therefore, to note the announcement of the Office of Scientific Personnel of the National Research Council, in its Bulletin No. 29, Feb. 6, 1946, to the effect that "the Office of War Mobilization and Reconversion has arranged with the services to expedite the release of personnel desired by the higher institutions in the United States." Details of standards and procedures are set forth in the bulletin.

Making a Program

EXTRAORDINARY circumstances attended the planning of the 1945 A.S.M.E. Annual Meeting held in New York during the last week of November. Until late in September it had been expected that the ban on conventions would limit the meeting to a local audience and a modest program. When the ban was lifted and the Meetings and Program Committee decided to go ahead with a full-scale national meeting, time was short, and, as a result, adequate notice of program details could not be given in advance and few preprints of papers were ready for distribution to prospective discussers.

To members of the Society who are unfamiliar with the time schedules which must be adhered to in preparing for a meeting it may appear that a couple of months should be sufficient to insure adequate advance publicity and a reasonable number of preprints. In point of fact, however, sixty days is all too short a time.

Consider first the time element in publishing the advance program. This program is published in MECHANICAL ENGINEERING, A.S.M.E. News Section. To be useful to the public it must appear well in advance of the meeting—several weeks rather than days—and it should be complete and accurate. The December issue of MECHANICAL ENGINEERING is mailed on November 26. As the 1945 Annual Meeting began on that day it was obviously necessary to publish the program in the November issue, which was mailed on or about October 26. Forms for the November issue closed on October 8. As decision to hold a full-scale national meeting was not taken until late in September, the work of making up the 1945 program had to be carried out within the period of a very few days. The result was an incomplete and inaccurate advance program.

About twenty-five program-making agencies—professional divisions and committees—were involved in planning the technical features of the Annual Meeting program. In addition there were committee meetings to be arranged, luncheons and dinners to be planned and provided with speakers, and chairmen and recorders to be assigned for every session throughout the convention. As the persons involved numbered several hundred and were scattered over a considerable portion of the United States, it is apparent that complete data for the program could not be assembled in the relatively few days available between the time that decision to hold the meeting was taken and the time the program had to be released for publication.

It should be clear from the foregoing explanation that the dead-line date for the release of the final program must be at least 60 days in advance of the meeting. But programs are not merely lists of papers and authors. Each paper and each event must be fitted into a session and each session must be scheduled for a specific time and place. This is the task of the Meetings and Program Committee. A five-day Annual Meeting affords 15 periods into which sessions can be fitted if every morning, afternoon, and evening is used. Luncheons and dinners are sandwiched into every noon and evening. One evening period must be kept clear of competing events because of the Annual Dinner, cutting down the available number of periods to fourteen. By tradition certain types of sessions are scheduled for certain days of the week. Care must be taken not to schedule for the same period two or more sessions at which papers will be given that are likely to appeal to the same audience—even engineers have not yet discovered how to be in two rooms at the same time or even to absorb two presentations simultaneously. And so the perplexities of program making grow as the numbers of papers and sessions increase from year to year. A month is not too short a time to assemble a program and iron out the conflicts of time and place. This means that 90 days in advance of a meeting the Meetings and Program Committee must have before it complete information covering all sessions, including copies of the papers to be presented.

By the time final program arrangement actually begins, 90 days in advance of the meeting, the work of the 25 program-making agencies should have been completed. How much time is required for this process depends on the procedures of the numerous agencies, and these are not uniform, but a conservative estimate adds another 90 days, which means that actual planning for a meeting must commence at least 180 days before the date of that meeting.

Consider what must be accomplished in that 90 days before the assembly of material for the final program can begin. First, the program-making agency, one of the divisions, for example, through its executive committee, or its program committee, or whatever group is charged with this responsibility, must decide on the number of sessions it will sponsor, the number of papers it will contribute, the general or specific subjects it will discuss, and must either select from papers offered to it those it will place on the program, or it must invite prospective authors to prepare the desired papers. If joint sessions are planned with other divisions or committees, the preliminary work is further complicated.

Within this 90-day minimum period the author must be invited to prepare a paper and accept the invitation. He must also prepare his paper and submit it to the sponsors of the session for review. In some cases, every member of a paper or review committee reads the paper. If only one copy is available this copy must be circulated among several reviewers. Each reviewer must submit his comments to the committee chairman and, under certain circumstances, the author may be asked to revise his paper in the light of reviewers' comments. Ninety days is a dangerously brief period in which to solicit a paper and have it written, reviewed, and possibly revised. Hence, many A.S.M.E. program-making agencies plan not 180 days but a year in advance of a meeting.

Experience has proved that the success of a technical session depends on the quality and quantity of the discussion. Intelligent discussion is difficult to prepare if the discusser has not had an opportunity to study the paper he is discussing. Hence preprints of technical papers must be available well in advance of a meeting. If the procedures outlined in the foregoing paragraphs are adhered to, the typscript and illustrations copy of a technical paper, carefully reviewed and possibly revised, but in any event in their final approved form, will be at Society headquarters 90 days before the meeting. In those 90 days it is possible for the editorial department to put the paper into printed form and deliver copies to the Meetings and Program Committee for distribution to discussers at least three weeks before the meeting. Only by this early submission of papers to the editorial department can preprints be assured in time to permit the careful preparation of discussion upon which the success of a meeting will depend.

During the 90-day interval between the acceptance of a technical paper for an A.S.M.E. program and the presentation of that paper at a meeting there is another step in which the co-operation of the author is needed for successful operation. The prestige of the author as well as that of the Society is enhanced by wide publicity in the technical press and the newspapers. The digesting of such papers is no easy task. Most of the technical journals devoted to the subjects discussed at A.S.M.E. meetings prepare accounts of technical sessions and abstracts of the papers presented. Copies of the papers are made available to these journals for this purpose; and in cases where the subject matter is of general interest, abstracts are prepared for the daily press. It is obvious that this service cannot be rendered by the Society if authors do not submit their papers for preprinting. If an engineer's work is worthy of being presented for discussion at an A.S.M.E. meeting and of being published by the Society, it is also worthy of as wide and as prompt dissemination as the technical and general press may be able to give it. To reach as large an audience as possible should be the aim of every engineer author. He can best accomplish this objective by submitting his paper in ample time for preprinting.

The involved procedures necessary for a successful meeting explained briefly in the foregoing paragraphs are set forth in the hope that they will clarify the reasons for asking authors for completed papers several months in advance of meeting dates. It is sometimes difficult for an author to understand why he should spend some dreary hours in the early summer writing a paper that is not scheduled for presentation until the following December. He owes it to himself, however, to get the task behind him as soon as possible and within the time limits set by the procedures of the Society. He will be amply rewarded for his co-operation. Members of the Society will have ample notice that he plans to present a paper and, if they wish to discuss it and thereby add to its value, they will have sufficient time for study and preparation.

Back of every good technical paper are months and even years of hard work and richly rewarding engineering experience. The presentation of a technical paper is an important, sometimes a dramatic, event. It should not be marred by hasty or indifferent preparation. The prestige of the author and the Society are at stake. Publication has a finality that should be soberly contemplated, for there the paper stands for present and future generations of engineers to judge.

Weights and Measures

CONSIDERABLE interest was aroused by mention in these pages, August, 1945, of a pamphlet by Walter Renton Ingalls, member A.S.M.E., entitled "Systems of Weights and Measures," in which reasons were presented for preferring the English system of weights and measures to the French, or metric system.

A more recent pamphlet by Mr. Ingalls, "Units of Weights and Measures," issued in 1946, lists and describes "units of measurement in the English system that are in common use, especially in U. S. A."

Starting with angular measurement as say ton, bag, bale, and barrel the list ends with ton, tun, unit, wearing apparel, wire gages, and yards. It makes interesting reading.

JET PROPULSION

By WILLIAM F. DURAND[1]

PROFESSOR EMERITUS OF MECHANICAL ENGINEERING, LELAND STANFORD UNIVERSITY. HONORARY MEMBER A.S.M.E.

IT WILL be understood that the device considered in the present discussion comprises three essential elements:

1 An air compressor, either of the centrifugal or axial-flow type. The latter, from its smaller diameter and adaptability to high rotative speeds, may be considered the more desirable of the two forms.

2 A combustion chamber located beyond the compressor into which liquid fuel is introduced, either as a fine spray or as vapor, and in which combustion takes place under the high pressure resulting from the action of the compressor.

3 A gas turbine, located beyond the combustion chamber, which receives the hot high-pressure gas from the combustion chamber and converts a part of the energy of this gas into the mechanical work of driving the compressor.

To these items may be added an exhaust passage leading from the leaving end of the turbine to the outside air, and preferably provided with some form of valve or device for varying the size of the exhaust opening in accordance with the conditions of operation of the device as a whole.

There is nothing basically new or novel in the idea of jet propulsion. The idea, itself, is as old as the reaction turbine of Hero of Alexandria who flourished some 250 years B.C. Coming down through the ages, it appeared again in Barker's Mill and in the rocket, notably as developed around the beginning of the last century by Sir William Congreve, an English army officer. In more recent times, jet propulsion was attempted by the British on the ship *Water Witch* some 70 years ago, and again during the third decade of the present century; in continental Europe, and especially in Germany, jet propulsion was the subject of active study and research.

PRINCIPLES OF JET OPERATION

The basic fact which determines the production of a propulsive thrust is the production of a sternward acceleration in a certain mass, the reaction from which gives the forward thrust desired. Defining the useful work as the product of this thrust into the forward motion of the object, the ratio of this useful work to the total energy of the jet is termed the propulsive efficiency.

Suitable analysis of the mechanics of the problem shows that the propulsive efficiency is directly dependent upon the ratio of the speed of discharge of the products of combustion to the speed of advance of the object (airplane). Normally the former of these two speeds is much larger than the latter. If, however, they could be made equal, the efficiency would be unity or 100 per cent. However, the same analysis shows that the increment of velocity impressed on the mass of gas discharged is the difference between these two velocities, which we may designate by u and V, the former the speed of discharge of the gas, relative to the plane, the latter the speed of the plane relative to the earth. The increment of velocity impressed on the discharged gas is then $(u - V)$. If, then, u and V are equal, the increment is zero and the propulsive thrust vanishes. We thus have the ideal limit condition of an efficiency of 100 per cent with the vanishing of the forward thrust. Actually, the propulsive thrust is measured by the product of the mass of gas discharged per second multiplied by the increment in velocity or in symbols by $M(u - V)$.

Now, coming back to the question of efficiency, we have at one extreme, 100 per cent for u and V equal. Then as u becomes greater than V, or V less than u, the value falls to 80 per cent for a ratio of u to V of 1.5; to $66^2/_3$ per cent for a ratio of 2; to 50 per cent for a ratio of 3 and so on gradually decreasing as the value of this ratio increases.

But the resistance of the plane in flight must be exactly balanced by the propulsive thrust, which as just noted is measured by the product $M(u - V)$. Hence, at any given speed of advance, the value of M must vary inversely as $(u - V)$, that is, the smaller $(u - V)$ and the higher the efficiency, the greater must be the mass of gas discharged to produce the needed thrust. And so, at the limit of u equals V, $(u - V)$ becomes zero, and M would need to be infinitely great to give the needed propulsive thrust. Put into plain language, this means that for any given value of the thrust, the mass of gas discharged must be greater and greater as V approaches u in value, with the corresponding increase in propulsive efficiency. But increase in the mass of gas discharged, of which by far the major part is air, means increase in the size and weight of the equipment, as well as lower temperature of the gases acting on the gas turbine.

But propulsive efficiency is only one factor of over-all efficiency, counting from the energy liberated by the burning of the fuel to the useful work of plane propulsion. Lying ahead of the propulsive efficiency is the thermodynamic efficiency, covering the transformation of heat into jet energy and mechanical work. Here, the principle of Carnot enters with the condition that the thermodynamic efficiency will increase the higher the temperature limit of the process. This means that higher thermodynamic efficiency calls for higher temperature of the gas acting on the gas turbine.

This complex situation calls, obviously, for a compromise between size and weight, thermodynamic efficiency and propulsive efficiency.

On the other hand, as the speed of the plane decreases relative to that of the gas discharge, the factor $(u - V)$ increases and the thrust per pound of gas increases, while the propulsive efficiency decreases.

However, the value of the gas discharge velocity u is naturally high. The mechanics of the situation tend toward velocities well beyond normal airplane speeds. It results that with an airplane speed of normal commercial value, for example, 300 to 400 fps, with gas discharge of 1200 to 1500, the propulsive efficiency will be low.

The practical result is that jet propulsion suffers in propulsive efficiency at low plane speeds, and only reaches acceptable values at the highest speeds obtainable under present conditions. These present highest speeds, moreover, are more easily realized at high altitudes than at low, so it results that the normal field for jet propulsion, the field in which it most nearly realizes its potential superior performance, is at high speeds and high altitudes.

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Presented at the Session on Research for National Security, Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

RESEARCH PROJECTS IN JET PROPULSION

Turning now to another phase of the broad subject of jet propulsion, we may inquire as to the present outstanding problems. What are the directions in which research and study should be directed in order to bring about improvement in this new form of propulsive engine.

These fall into two main classes which may be denoted:

1 Problems of combustion.

2 Problems of materials of construction.

To these may be added the following:

3 Problems of design.

4 Problems of operation.

5 Problems of supersonic speed.

Combustion. The problem of combustion comprises the entire field of the combustion of a fluid fuel under the conditions prevailing in a jet-propulsion engine, that is, in a rapidly moving current of air in quantity greatly in excess of the amount required to furnish the oxygen needed for combustion. The ends sought are as follows:

1 The maintenance of active combustion under all rates of fuel flow as determined by the throttle opening.

2 The complete combustion of the fuel within the minimum volume and within the limits of the combustion chamber itself.

3 Assured ignition and pickup of combustion from shutdown of the motor or from idling at any altitude and any speed of the plane.

Before oxygen can unite with hydrogen or carbon, the latter two substances must be in the free molecular or atomic state. This means that the fuel must pass from the liquid to the vapor phase as a preliminary to the phenomena of combustion. There are therefore available two techniques for the introduction of the fuel into the combustion chamber:

(*a*) Introduction in the liquid phase in the form of a fine spray, the particles of which flash promptly into vapor, and the molecules in vapor form proceed to break up into their constituent atoms which are then free to unite with the oxygen.

(*b*) Vaporization of the fuel outside of the combustion chamber and introduction of the fuel in the vapor phase into the chamber and into contact with the oxygen carried by the air.

Both of these techniques have been tried, the former appearing on the whole to have, so far, given the most satisfactory results.

There remains, however, a wide field of research directed toward improvement in both of these methods of fuel introduction into the zone of combustion.

The problem of flame propagation is also a phase of the problem of combustion needing further study. If the zone of combustion is to be limited to desirable lengths, the velocity with which the flame can spread through a mass of air and fuel vapor is a determining factor of the volume within which, with the rapidly moving current of air, the combustion can be completed. Here again is a field open for further study.

The maintenance of combustion in the rapidly moving current of air is a condition which has presented trouble to meet. Some form of baffle or shielding of the actual inlet point of the fuel entrance has been found needful. The best form and arrangement of such shield or baffle is a problem well worthy of further study and trial, especially under varied conditions of flight as regards altitude and speed.

Materials of Construction. The major problems under this head relate to a search for high-temperature-resisting metals with other properties suited to the making of turbine blades. Reference has been made to the thermodynamic efficiency as dependent on the upper gas temperature; the higher the temperature, the higher the efficiency.

In 1941, when special attention became directed to the matter of high-temperature-resisting metals, 1200 or 1300 F was about the limit which could be attempted with the best materials that metallurgical science could provide. During the years of the war, active research was carried on, with the result that the upper limit of gas temperature was raised some 400 to 500 deg. This, however, should be considered only as a way station, and active search should continue for new combinations of metals carrying the temperatures to still higher levels.

There are at least two other directions in which search should be made for dispositions permitting the use of higher gas temperatures. These are the use of ceramic-coated blades and the cooling of the blades.

Ceramic materials in themselves are lacking in the physical properties of strength for use as the sole material for the blades of a gas turbine. But the combination of a ceramic coating to take the impact of the hot gas backed by a metal for the needed strength, appears to offer definite hope. Already these possibilities have received attention, with definitely hopeful indications. The principal problem in such a construction is the finding of two materials, metal on the one hand and a ceramic on the other, with a sufficiently high melting point, which will bond with the metal and with a coefficient of expansion sufficiently near that of the metal to insure against cracking and flaking off under the wide range of temperatures to which the blades are subjected.

For cooling of the turbine blades, three methods have received some study. In one method, the blades are made hollow and adapted to the flow of cooling air outward through them. In a second method, the blades, in the course of a revolution, pass through a sector of the circle in which is cooling air instead of hot gas. There is thus a periodic heating and cooling of the blade which permits the impact of relatively high-temperature gas. This method was employed in certain gas turbines of German design with what were claimed as very satisfactory results.

Still another method of cooling has been proposed, which provides for the flow of a cooling liquid (water or liquid fuel) through a passage in the root of the turbine blade. This method depends on the flow of heat from the blade or vane itself to the relatively more massive root, encased in the turbine disk and carrying a passage for the flow of the cooling fluid. The idea appears to present distinct promise and should receive adequate trial and test.

All of these methods of approach to the problem of higher temperatures for the gas entering the turbine offer definite prospects of useful results and at the same time furnish an indication of the importance of the problem and of the degree of attention which it has already received. It stands as a continuing challenge to metallurgists, to engineers, designers, and scientists to continue active work on this problem, the solution of which will mean so much in the improvement of the thermodynamic efficiency of the gas turbine and in its wider adaptation as a prime mover in competition with the present accepted forms of reciprocating internal-combustion engines.

Design. Design is a broad term covering materials, form, and arrangement of parts as well as individual function. Jet-propulsion engines represent a combination of many materials, diverse forms, with multiple arrangement possibilities and functions. It is by no means sure that the present conventional forms of such engines are the best possible. Rather, it is to be expected that new materials, other forms, and arrangements of parts may well present marked improvement over those characteristic of the present-day types and forms. Here is a fruitful field for study and investigation which should occupy the attention of those concerned with the further improvement of the jet-propulsion engine.

Improvement in turbine-blade materials has already been singled out for special mention. In addition there is the problem of attaching the blade to the turbine disk, the problem of the main bearings under the high rotative speeds (10,000 to 20,000 rpm) characteristic of jet-propulsion equipment; the problem of the best material for the shell of the combustion chamber, as well as the problem of the best size and arrangement of openings in the shell of the chamber for the admission of the air; the problem of the best mode for handling the excess air in such way as to provide needed cooling effects on parts of the equipment in contact with the hot gas; the problem of the best form and arrangement of variable partial closure for the exhaust tail pipe and of the control of this valve by the pilot; the aerodynamic problems of the best form of the rim of the entrance opening at the nose of the engine, of the form and arrangement of the burners within the combustion chamber in such fashion as to present the minimum loss of pressure in the air flow through the chamber, and the best form and proportions of the tail pipe.

Operation. As the proof of the pudding is in the eating, so is the proof of a jet-propulsion engine in its performance in the air. A perfect performance implies perfect and prompt following of the throttle up and down, continuous and regular operation under all conditions of speed and altitude with immediate pickup from engine-off condition under any altitude, attitude and speed of the plane.

Jet-propulsion engines at the present time hardly meet this specification of performance. There may be irregularity in the combustion in following the throttle over a certain part of its range of operation. There are zones of operation, as defined by speed and altitude, within which it is difficult or impossible to start the engine from the engine-off condition.

This opens a broad field of development research and study with trial of the engine in the air followed by corrective changes and retrial, with renewed changes and further trial, all with a view of finding the cause of difficulties and trouble, with suitable corrective changes in the engine.

Supersonic Speeds. The chief condition which gives significance to jet propulsion as a substitute for the conventional propeller is the freedom of the former from loss of efficiency under speeds closely approaching, or equal to, or beyond the speed of sound in air—about 1140 fps at sea level. The conditions are those of gradual approach and begin to appear in evidence at speeds around 70 per cent of the speed of sound.

However, while jet propulsion in itself is free from loss of effect or efficiency at speeds subsonic, sonic, or supersonic, the same is far from true for the remainder of the airplane. This means that at speeds at which jet propulsion can be expected to come into its own as a means of airplane propulsion, the airplane as a whole and in all its parts is subject to the special conditions arising at these high speeds.

SONIC AND SUPERSONIC SPEED STUDIES NECESSARY

This carries the condition that fundamental and extended research on the aerodynamics of sonic and supersonic speeds is a collateral line of investigation of the highest importance in connection with the development of such speeds for aircraft. The aerodynamics of low and present commercial speeds is well understood in theory and has been the subject of thoroughgoing research in all the leading countries of the world. Only more recently has the importance of the aerodynamics of sonic and supersonic speeds forced itself on the attention of designers and aeronautic engineers.

At sonic and supersonic speeds there is formed in the air in contact with the moving object a shock or compression wave which travels with the object and modifies in extreme degree what may be called its aerodynamic form. The laws of fluid flow around the object are profoundly modified, the resistance or drag of the object is greatly increased, and the distribution of pressure over its surface undergoes extreme changes. Due to this latter condition, control surfaces properly adapted for use at normal speeds may fail utterly to furnish control at sonic and supersonic speeds.

All of this means that hand in hand with the study of ways and means for the improvement of the jet-propulsion engine in itself, there must go continuing and active research and study of the aerodynamics of speeds through the subsonic, through the sonic, and on into the supersonic.

Owing to the large amounts of power required for the operation of wind tunnels at these high speeds, much or most of the work thus far done by way of direct laboratory experimentation has been on small-scale models and under the conditions of two-dimensional flow. This does not tell the whole story and what is needed is larger wind tunnels with larger models tested under the conditions of three-dimensional flow.

The National Advisory Committee for Aeronautics has appreciated these conditions and has been keenly awake to the need of such investigation. Funds have been provided and the committee will soon have in operation the largest supersonic wind tunnel in the world, capable of testing relatively large-scale models under the conditions of three-dimensional flow. In addition, the committee has a number of smaller or special-purpose sonic and supersonic wind tunnels and is planning for extended lines of research along lines of investigation calculated to throw much needed new light on the aerodynamics of sonic and supersonic speeds.

CONCLUSION

If any broad parallel may be assumed between the development of the present highly refined and efficient aeronautic internal-combustion engine and the future growth and improvement of the jet-propulsion engine, the latter has before it a brilliant and impressive future. In its present state, it may be properly compared to the internal-combustion engine of forty years ago, in the very beginning of the aeronautic era. It is futile, at the present time, to predict in any detail the characteristics and operative performance of the jet engine of a quarter of a century hence, but it will undoubtedly occupy a highly important place in the field of aircraft propulsion, perhaps of exclusive use for the higher range of the airplane speeds of that future day.

Gas Producer Report

THE National Research Council of Canada has recently issued the second general report on "Gas Producers for Motor Vehicles," by E. A. Allcut, member A.S.M.E., and R. H. Patten.

This report describes work done under the direction of the Subcommittee on Producer Gas between November, 1943, when the First Report (N.R.C. No. 1220) was prepared, and September, 1944, when the war emergency program was completed.

The results obtained from various producer tests and special tests are summarized in the report and the possibility of future development outlined.

A modification is suggested in the standard shatter test for charcoal fuels. Cold-weather operation was studied and tests made on engine heaters are described in the report.

A study of the possible prediction of road performances and gear ratios from stationary engine-tests is included among the appendices, and recommendations are made concerning safety in the design, manufacture, maintenance, and operation of producer gas plants. The possible use of producer gas in a postwar program is envisaged.

RESEARCH NEEDS *of the* NAVY

By REAR ADMIRAL H. G. BOWEN

DIRECTOR OF RESEARCH AND INVENTIONS, NAVY DEPARTMENT. HONORARY MEMBER A.S.M.E.

EVERYONE knows what a navy is, but I doubt if many of the characteristics of our Navy are known to all, and until they are known and realized, the need and the dependence of the Navy on research cannot be fully recognized.

Ours is the largest navy in the world, but that isn't all. It operates the largest ship construction and repair activity in the world, and in this capacity it is one of the largest employers of labor. It is the largest aggregation of horsepower and the largest example of mechanical engineering in the United States. It is the only activity in the United States which requires the support of every type of engineer and scientist.

THE NAVY'S PAST POSITION IN RESEARCH

For some time, the Navy has operated a number of laboratories, including the Naval Research Laboratory, the Model Basin, the Engineering Experiment Station, the Boiler and Turbine Laboratory, and the Naval Ordnance Laboratory, to mention a few. The Navy has also employed the services of outside laboratories, both industrial and university, as well as other government laboratories, and will continue to do so.

The Naval Research Laboratory, with assistance from others in some cases, had developed radar, underwater supersonics, solid oxygen, solid gasoline, closed combustion systems, hydrogen-peroxide torpedoes, the instrumentation for work on precipitation static, sonoradio buoys, concentration of U-235 by thermal diffusion, and a host of other things before the war. The vital part which this laboratory played in preparing the groundwork for the War Research Agencies with their command of unlimited funds and their unlimited access to scientific personnel cannot be overestimated. In fact, the success of these War Research Agencies in many fields is predicated on early work done in the Naval Research Laboratory in time of peace.

HIGH-PRESSURE HIGH-TEMPERATURE STEAM

One of the least spectacular of the war developments and one which until now has not been disclosed to the public has to do with high-pressure high-temperature steam. The controversy that raged on this subject may be remembered by some. But the results of this, at that time daring and radical innovation, have never been reported to the public. High pressure high temperature is an inadequate expression for this development, because much more transpired than raising pressure aboard ship to 600 psi, and the temperature of the steam to 850 F. It represented a complete break with the past. It meant the complete elimination of the influence of Parsons Limited in the Navy's Bureau of Engineering and indicated that engineering in the Navy had arrived at its maturity and had entered an independent existence.

In view of the pressures and temperatures employed in the central power plants of the United States at that time, the pressures and the temperatures which were adopted then and which are still standard for our Navy were not high. This change, however, was relatively great when we consider the previous navy and maritime standards. The introduction of these pressures and temperatures was accompanied by a complete re-engineering job of every ship that the new Navy was building. By using turbines of American design, we were able to reduce the number of blades in one instance from 17,000 to 1700 and produce a much more rugged, reliable turbine. Turbine speeds were greatly increased until we reached 10,000 rpm for an idling cruising turbine.

Entirely new boiler designs were adopted which embodied superheat control, economizers, air casings, and a capacity for 40 per cent overload. Feed systems with oxygen removers were installed. Double-reduction gears were required, owing to the high speed of the turbines and space limitations. Emergency Diesel-electric generators were adopted. The whole electrical system was changed from direct to alternating current. Flameproof cable was employed. Steam piping without slip joints made its appearance and alloy steel replaced carbon steel for heavy duty.

The result of this program was that, by the time of Pearl Harbor, the Navy had completely redesigned, proved at sea, and standardized all of its machinery for both surface ships and submarines.

This is one of the most important periods through which engineering in this country has ever passed. It marked the end of the ship and engine builder. From then on a shipyard became an assembly plant, and the way was paved for the assembly plants which were so characteristic of this war, especially in the production of merchant shipping.

The machinery used in the war program was the result of millions of dollars spent on research over the years by the builders of turbines, reduction gears, electrical machinery, boilers, cables, Diesel engines, and many other machinery items.

For the first time in history, at least in this country, all the boilers, pumps, gears, and turbines associated with one shaft of a ship were set up ashore and operated extensively under cruising and full-load conditions. It represented an installation in the shop of a turbine builder of over 30,000 hp of brand-new equipment on one shaft. Later, the Boiler Laboratory was equipped to perform this type of turbine testing.

Finally, a destroyer was re-engined and partly reboilered, and this destroyer has operated throughout the war at 1300 psi pressure and 925 F.

Looking backward, it is rather difficult to imagine what all the controversy was about. But there was a controversy. It was very spirited and almost all of the naval and shipbuilding fraternity was arrayed against the proponents of this new engineering which was, after all, American engineering based on successful research.

In order to interest commercial shipyards in building battleships with high pressure high temperature, it was necessary to include clauses in the contracts to the effect that the Government would hold itself responsible for the cost of any alterations or changes found necessary in the engineering plants of these vessels based on the Navy's experience with high pressure and high temperatures by the time the vessels were completed. In the case of one of these battleships, it was necessary for the Navy Department to purchase and furnish to the contractor the high-pressure high-temperature machinery involved. The contractor would not assume the responsibility

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for any machinery which involved such a violent break with tradition.

"DOUBLE OR NOTHING"

A great responsibility was placed upon those who were forced to make this decision. They were confident that a war was fast approaching, which would not permit any slow and deliberate determination of which school of thought was correct. It was double or nothing. They did not dare to run the risk of building and investing billions in an obsolete Navy. They took what at that time seemed to be, to the overwhelming majority, a great chance, and they won.

It is well known, of course, that the most economical results with high-speed turbine installations occur when turbines are operated at or near full speed. It was argued against this new-fangled machinery, that a naval vessel's operations would be mostly at low speeds, but the war settled that. A large percentage of all operations were at high speeds, and the increased fuel economy over what we might have had was of great assistance in the long reaches of the Pacific and to those who labored in logistics. Unbelievable mileages without repair were the rule and not the exception. The machinery proved to be as rugged and reliable as its proponents had prophesied and the amount of repairs required by ships during the war was unbelievably small. Our machinery was proved in war to be far superior to that of any other navy.

Other examples could be given concerning our most successful multicylinder Diesel-electric submarines, whose design some thought so radical as to imperil the effectiveness of the Navy. The splendid record of our submarines in the war has quieted that criticism. The Navy and the nation owe a debt of gratitude to American industry, and to such organizations as this Society, which are firmly founded on research, and the best ideas of which the Navy has incorporated in its vessels and equipment. It is still the policy of the Navy to do just that!

The foregoing gives a slight idea at least of the immense extent to which the Navy has profited by the research done in its own and in commercial research laboratories.

RESEARCH OF TODAY AND TOMORROW

Some time ago there was established in the Navy Department in the Secretary's Office, the Office of Research and Inventions. It comprises the former Office of Research and Development, the former Patent Office, the Naval Research Laboratory, and the Special Devices Laboratory. This change has not altered the position of the Bureaus, the Navy laboratories, other government laboratories, or the industrial and university laboratories in the research and development field.

This office has an allotment of money and is in a position to make contracts for research and development whenever that appears to be necessary. It is preferred, however, that the bureaus should continue their usual practice of obtaining their research in government or outside laboratories as has been their practice in the past. This office is prepared, however, to place contracts for research in the general field and in any particular field where it thinks research is required or where research cuts across bureau lines. This office exercises a general surveillance over all research programs, not only to see that all parts of a program are provided for, but also to be of assistance to the bureaus in cases where aid is required. This office also acts as a central point in the Navy Department to which may come individuals or outside activities not familiar with naval organization and who desire assistance in beginning relations with the bureaus on research subjects.

This office also maintains technical files and records, and by bulletin keeps appropriate agencies of the Navy Department informed on technical ideas which may be of interest to them. It is proposed in the future that this technical library be so expanded and perfected that it will be the starting point for any engineer or scientist in the Navy Department who is embarking on an extensive investigation prior to the setting up of a new problem.

We are now entering a period where research and development are uncertain and results are clearly unpredictable, but we still need assistance. The glamour of the atomic bomb and of the German V-2 bomb has tended to obscure many developments of the future which require a great amount of research and which in themselves are epochal.

Propulsion Systems. The revolution in propulsion occasioned by the advent of the gas turbine and the jet is something which will affect not only the lives of every one of us, but will have a profound influence on a great many elements of industrial, commercial, and social life. There is a great amount of work going on all over the country on these propulsive elements which have suddenly appeared in our midst, and without benefit of the extensive background of research which eventually has to precede all sound development and progress.

The Navy, of course, is vitally interested in the gas turbine for the propulsion of ships, and the rocket and the jet for the propulsion of missiles and aircraft.

Supersonic Speeds. We are now at the threshold of supersonic speeds. To achieve progress will involve a tremendous amount of research in an almost totally undeveloped field. It will require the expenditure of a great deal of money for the necessary facilities with which to advance our knowledge.

I have said that much work is going on without the benefit of an extensive background of research. Let me elaborate on what I mean.

Guided Missiles. Take guided missiles as just one example of the research and engineering required of the future.

A guided missile obviously consists of or requires air frames, power plants, fuels and combustion, guiding systems, servos and control equipment, warheads and fuses, launching methods, and training.

The required research and engineering involves at least the fields of aerodynamics, physical and mechanical properties of propellants, explosives and fragmentation theory, fluid flow, general chemistry, exterior ballistics, applied mathematics, nuclear physics, mechanics, chemistry and physics of combustion, meteorology, ceramics, metallurgy, heat transmission, electronics, and thermodynamics.

Radar. The development of radar was accompanied by a tremendous improvement in all branches of electronics, and this opens up vast fields for exploration with the promise of multichanneled communications and blind-landing systems, to mention just two of the many possibilities. Electronics will also enable us to endow our missiles with a sense of sophistication or discrimination to an extent which a few years ago would have sounded impossible.

Atomic Energy. The harnessing of atomic energy is of course a vital subject and of which of late we have heard a great deal. If the development of nuclear technology follows the usual course of development, its first application will probably prove to be too expensive for immediate commercial use, but not too expensive for immediate naval use. It may well be that the greatest strides which we will make in the next few years in harnessing atomic energy will be in connection with its employment aboard ship.

FOSTERING SCIENTIFIC STUDY AND TRAINING

Those of us who have been on active engineering and research work recognize one great fundamental principle, i.e., the work is only as good as the men who do it. If we are to con-

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RESEARCH NEEDS *for* WEAPONS

By MAJOR GENERAL G. M. BARNES

DIRECTOR OF RESEARCH AND DEVELOPMENT, ORDNANCE DEPARTMENT, U. S. ARMY. MEMBER A.S.M.E.

THERE has been much discussion about what the future plans of the War Department should be in connection with research and development, and it is gratifying to realize that there is also a great deal of national interest in the matter. I sincerely hope that we will not repeat the mistakes that were made at the end of World War I by neglecting the subject entirely and failing to obtain the necessary funds for this purpose.

ORDNANCE RESEARCH AND DEVELOPMENT DURING THE WAR

In order better to understand the problems which confront the War Department in the research and development field in the postwar period, it may be helpful to review how research and development were conducted by the Ordnance Department during the great war which recently ended. What transpired then constitutes the background for the procedure which should be followed in the future.

In 1938 it was clear to all of us in the War Department that a second great world war was close at hand. The Ordnance Department proceeded aggressively to improve its position in regard to weapons, within the limitations imposed by available funds. The Congress also realizing that an emergency confronted this country fortunately increased the Ordnance appropriations considerably that year. Prior to that time the annual appropriations had been approximately $10,000,000. In some cases it had gone as low as $6,000,000 annually, and not for research and development alone, but for the operation of the entire Ordnance Department, arsenals, depots, and proving grounds. Yet, when war came, that responsibility rose in money value in one year to more than $50,000,000,000.

For the fiscal year 1938, the sum of $24,000,000 was appropriated. For the fiscal year 1939, this sum was further increased to $112,000,000. Using these sums, programs were vigorously inaugurated to complete the development work on new items of ordnance and to have the combat services test and approve them. The six government arsenals were directed to complete the drawings and specifications for this equipment and to make ready for quantity procurement in industry.

It is quite possible that our country was saved in this war by the appropriation of $1,250,000,000 for the Ordnance Department, which became effective for expenditure in September, 1940. Weapons manufactured with these funds made it possible for the British using our tanks and ammunition to stop the Germans at El Alamein, and the Army and Marine Corps to halt the Japanese in the battle of Guadalcanal. Immediately upon receipt of this vast sum of money, it was possible for the department to release fully its plans for the industrial mobilization of the country. These plans had been carefully worked out during the preceding 20 years. It is my opinion that the plans formulated in the peace years for industrial mobilization saved at least a year in the procurement of those vital weapons so necessary to the safety of our country and our allies during those critical days.

MANY MODERN WEAPONS LACKING

As soon as this program, based on previously developed weapons, had been inaugurated, it was foreseen that it would be immediately necessary to implement it with a program for the development of new and more effective weapons. There were many gaps in our list of ordnance equipment, especially in the field of more expensive weapons, such as heavy artillery, for the development of which funds had been lacking and which required a year or more to design and place in production. It was also fully realized that this great task could not be accomplished at our arsenals or with the small trained nucleus of Ordnance officers and Ordnance engineers then available in the Department. The only hope of success was to place the program with the scientific and engineering talent of the country, where facilities suitable for this purpose were available. This became the policy of the Ordnance Department.

The work of developing new weapons was decentralized throughout the United States, maintaining a strong centralized control in the Office of the Chief of Ordnance in Washington, and utilizing as effectively as possible the available qualified personnel in the Ordnance Procurement Districts and at the arsenals to advise and assist those who undertook the specific assignments.

For example, companies not familiar in any way with ordnance work, but possessing adequate engineering facilities, were contacted. Contracts were placed with them for the development of specified items. Descriptions of these items were furnished by the department, based on action of the Ordnance Technical Committee on which were representatives of all of the using arms and through which the characteristics desired by them are established. Wherever possible one or more trained ordnance officers and engineers were sent to the company to assist in the work. Any "know how" at the arsenals, where an effort had been made to keep alive the ordnance art on certain items, was made available to the concerns involved.

To show how the plan functioned, the design of the 120-mm antiaircraft mount was placed with the Link Belt Company of Chicago. Engineers of this company had given no previous consideration to this materiel. However, they set to work designing this complicated piece of equipment under the direction of the Research and Development Service of the Ordnance Department and with the help of ordnance officers and engineers sent to the plant. This materiel, which is complicated mechanically, functioned satisfactorily the first time it was fired and was subsequently placed in quantity production.

ONE THOUSAND NEW ORDNANCE ITEMS DEVELOPED

Hundreds of items were developed in this manner, and at the peak the Ordnance Department had more than 1400 such development projects in progress. During the last three and a half years, more than 1000 new items of ordnance were so developed, tested at the ordnance proving ground, again tested by the combat arm which was to use the weapon, accepted by them, standardized, and placed into quantity production. In this way the weapons in this war were developed, manufactured, and placed in the hands of troops throughout the world.

Our plans for the future peacetime development of weapons are based upon this war experience, and the full realization of increasing fluidity of warfare in an age of unusual scientific

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achievements. These plans are geared to fit the funds which the Congress provides for the purpose. The success of our ordnance research and development program in the greatest war of all times was due to the co-operation and combined effort of the science-industry-ordnance team. In my opinion everything possible should be done to preserve the continuity of that team in the years of peace which lie ahead.

PLAN FOR PEACETIME ORDNANCE RESEARCH

We are all convinced after our war experience of the necessity of keeping our weapons up to date. It takes time to develop and manufacture materiel required by modern warfare. We may not be so fortunate in the future with respect to time as we have been in the past. We believe that the best insurance against war is to be prepared. This will require much long-range research and development work looking to weapons the future may demand. These reasons are sufficient to compel all of us to continue the close association of ordnance, science, and industry, which together have produced the weapons in this war, and which working together in time of peace will keep our country always in the lead.

It is the present plan of the Ordnance Department to request from Congress an appropriate and fixed sum of money each year for research and development. About one third of these funds are to be utilized at our government arsenals and proving grounds, which are laboratories engaged in fields of endeavor not ordinarily found in commercial industry. Approximately two thirds will be used in placing contracts with research institutions and with manufacturers having strong scientific and engineering research organizations and facilities suitable for the development of new weapons of the various types. Our war experience has taught us that this is the best possible way in which to conduct research and development in ordnance for the War Department.

During the war, companies willingly accepted research and development contracts from the Ordnance Department because of the desire to win the war. There was no question of dividing a company's energies between the projects for the War Department and its peacetime commercial work. Now that the war is over, however, it may be more difficult for these companies to carry on research and development for the Government, since this may interfere with their commercial interests. Yet, in the interest of national security, ways must be found whereby this can be done, and from a national standpoint money spent wisely on military research and development pays dividends in addition to assuring preparedness.

FAR-REACHING BENEFITS TO INDUSTRY

Benefits that accrue to science and industry from such work are many and far-reaching. Armament development, as carried on by the Ordnance Department in co-operation with the technical and scientific organizations of the country, has been responsible not only for our superiority of weapons in time of war, but also for many of our advancements in the standards of living in the years of peace. An examination of the record over the many years since the Ordnance Department was established in 1812 will show that the research sponsored and directed by the department has had a profound influence on the scientific and industrial developments of the country. Familiar items include the principle of the interchangeability of parts, through which American industry has attained the very highest in quantity output with lower unit cost, and pioneering work in metals to meet ordnance requirements.

Gun-making in the United States, as carried out by the Ordnance Department, pioneered in the field of new and stronger metals. The development and improvements in cast iron and in steel contributed by the Ordnance Department, notably at Watertown Arsenal, made available to industry better metals and better manufacturing methods, to the lasting benefit of the nation as a whole. Prior to and during the Civil War, the department did much to improve cast iron for cannon; then after the Civil War, it made the startling proposal and was equally aggressive in insisting that guns be made of steel which was then only in an embryo stage in industry. As a result, steel was adopted to replace cast iron for guns. This was the start of high-grade steel in this country.

In 1880 the requirements for high-carbon steel for making guns were fully 50 per cent more severe than were the general industrial specifications. The Ordnance Department introduced alloy steels in specifications for ordnance materiel and prescribed the use of nickel steel at a time when there was little or no commercial use for alloy steel in this country. By insisting on higher strength and better quality, the department encouraged industry to improve steel-melting practices, to better forging techniques, and heat-treatments to meet the increased requirements.

The tremendous influence for good to the country as a whole of this procedure no one now questions, although few realize the history and significance of these developments. This procedure is typical of many others in ordnance research and development which have had great significance to science and industry. I might mention a few more: Just prior to the war, the Ordnance Department at Watertown Arsenal developed the revolutionary method for making cannon by the centrifugal-casting process. This process was used successfully during the war and was especially important in meeting early requirements for cannon, until the forging industry could be converted and expanded to help carry the load. Approximately one third of all the cannon made in this country during this emergency were produced by the centrifugal-casting process. Applications of the centrifugal casting of steel cylinders for commercial purposes followed this development.

At the beginning of the war Ordnance designed its guns based on steel having an elastic limit of 65,000 psi, which up until that time was regarded as a figure which industry could meet in this type of steel. During the war requirements arose for very thin guns of large caliber and great striking power which could be mounted in tanks and other types of armored fighting vehicles. If steels of 65,000 psi had been used, the weight and size of the gun would have been prohibitive and would not have permitted such installations. Very light guns were designed for these tanks, utilizing steels with elastic limits as high as 160,000 psi. Thus the 75-mm gun of the first world war weighed 1015 pounds, while the 75-mm gun of this war of equal power weighed 410 lb, a direct measure of improved metallurgy. Forging manufacturers were at first hesitant in accepting orders for these highly stressed guns with the requirements for strength and ductility which were specified. However, we successfully made these guns to these high physical characteristics, and the compositions and heat-treatments required to develop them are available to meet commercial needs. Thus during this war, as at the time when steel was first coming into use in this country, science and industry responded to meet the need specified by the Ordnance Department which has resulted in improved materials for industrial applications.

TORQUE-CONVERTER TRANSMISSIONS PERFECTED

The Ordnance Department pioneered during the war in the use of torque-converter transmissions for tanks and heavy tractors. By combining the torque converter with the hydromatic transmission, the so-called torqmatic transmission was evolved. This made it possible for the untrained soldier to drive the heaviest tank skillfully. These newly developed

transmissions will be available for use on heavy commercial vehicles and tractors.

In the amphibian operations so extensively carried on in this war, it was necessary to unload great quantities of wheeled vehicles from various types of landing craft. It was not always possible to bring the ship close enough to the shore to avoid crossing water with the trucks as they were unloaded. This led to the waterproofing of various ordnance vehicles so as to make it possible for the trucks to be driven ashore even in 6 feet of salt water. At first improvised applications were made to trucks in the field to make this possible and later the electric circuits of the trucks and tanks were redesigned to make them entirely waterproof. Our latest tanks and trucks are equipped with these waterproofed electrical systems. Undoubtedly there will be commercial applications for these developments.

CONTRIBUTIONS TO WELDING ART

Welding research and development, sponsored by the Ordnance Department prior to and during the war, resulted in the extensive application of this process in the manufacture of ordnance materiel. We used welding in mass production and to a far greater extent than did our enemies. In welding gun mounts, gun motor carriages, and other fighting vehicles, it not only made improved designs possible but also with less weight gave increased performance and safety in operation. One of the notable achievements in this war was the development of satisfactory techniques for welding armor plate, and the change from riveted to all-welded structures in our fighting vehicles afforded improved design, safety, and performance. These developments in welding notably of high-strength steels will have many commercial applications where weight is an important factor. Research in welding must continue.

ADVANCES IN FUELS AND LUBRICANTS

Fuels and lubricants are the lifeblood of materiel used in a mechanized army; without them it could not move. The ordnance research and development program during this war produced several outstanding improvements in this field. Early in the war, supply considerations indicated the need for a single all-purpose fuel for use in all combat and transport equipment. On the surface this does not appear to be a particularly difficult problem, because the 80-octane premium gasoline procured for military use was commercially available. However, this fuel was provided in three grades to dovetail with the commercial practice of supplying fuels adapted to the season and to the area in which they were to be used. They must be stable fuels, capable of withstanding long-time storage under severe conditions. Accordingly, the Ordnance Department with the assistance of the Co-ordinating Research Council initiated and completed an extensive test program which has given us an all-purpose combat gasoline.

Another important achievement in the field of fuels and lubricants was the development of a single year-round recoil oil for all artillery weapons. Satisfactory performance of artillery depends largely upon the oil used in the recoil mechanism. This oil must be fluid and sufficiently light to permit normal recoil at low temperatures, yet must be viscous enough to prevent overrecoil at high temperatures. The task of developing an all-temperature recoil oil was a difficult one, and much of the research involved was of a pathfinding nature. This required an extensive ordnance program in which the National Defense Research Council co-operated. Virtually every step was new. The effect of the molecular weight of the viscosity-index improver had never been determined, nor had any attempt been made to develop a blending formula. A blend was finally developed with the desired characteristics and subjected to thorough tests which included firing of approximately 135,000 rounds of ammunition at temperatures from minus 45 F to plus 140 F. This oil is now in service and is proving its worth.

The global war created entirely new problems in rust prevention and surface preservation for the Ordnance Department. To meet those problems, several grades of preservative oils and rust-preventative compounds were developed. Preservative oils serve a dual purpose, acting not only as a rust preventative, but in many cases as a lubricant for those surfaces to which they are applied. Aircraft cannon and machine guns corrode with unbelievable swiftness when subjected to the rapid change to rarified air of high altitudes from the intense humidity of sea-level atmosphere in the tropics. Such rapid changes were usual in combat operations in the Pacific area, and an entirely satisfactory oil to meet these requirements, both from the standpoint of rust prevention and operation at high and low temperatures has been developed. A medium-preservative oil has also been developed for use on all ground weapons in hot humid areas, particularly during landing operations. It has proved very satisfactory.

Another important development was an engine oil which would furnish adequate protection to gasoline engines against rust, and which would at the same time serve as a lubricating oil for limited periods of operation. This resulted in tremendous saving of man-hours, labor, and material. Another noteworthy advancement was the development of the film rust-preventative compound for use on deck-loaded equipment, and employed extensively in the Pacific to protect nonmoving parts under severe conditions. It is the most versatile of all rust-preventative compounds because it can be sprayed, dipped, or brushed on surfaces. When dry, this material forms a thin film having a high melting point, which affords very good protection for indoor or outdoor storage and against salt water.

Methods have also been developed for packing and packaging of materials to meet unusually severe transportation and storage conditions and to insure against undue deterioration from extreme weather conditions and attack on fungi. In some instances, plastics have served a useful purpose for items susceptible to fungi attack. This was a major problem which is now under control.

All of these developments have been carried out with the active co-operation and assistance of the fuels and lubricants industry, and many will find useful applications in the commercial world.

ORDNANCE RESEARCH STIMULATING TO SCIENTISTS AND ENGINEERS

In addition to the many examples of the importance of research and development in ordnance to commercial manufacturers, undoubtedly the greatest benefit of all came about through the stimulation of the scientists and engineers in our laboratories and commercial plants, who were engaged in the solution of difficult ordnance problems. In many companies these engineers had worked year after year on a narrow range of problems involved in their commercial work. During the war these companies undertook problems which were entirely new to them, requiring the greatest ingenuity and skill in their solution. Many manufacturers have told me that their research and development and engineering organizations have been greatly stimulated and strengthened throughout the war by their successful solution of these varied and difficult ordnance problems. Ordnance covers a wide range of problems in the solution of which suggestions and ideas helpful to industry are obtained.

It is realized that most companies will be unable to assign many workers to ordnance activities for the next few years or

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The FUTURE *of* RESEARCH *and* DEVELOPMENT

By MAJOR GENERAL BENJAMIN W. CHIDLAW

DEPUTY COMMANDER, ENGINEERING (T-3), AIR TECHNICAL SERVICE COMMAND, WRIGHT FIELD, DAYTON, OHIO

PROBLEMS of keeping the United States pre-eminent in the field of military aviation are approached many times in these new days of peace from what the boys in the laboratories call the "Buck Rogers" angle.

Imaginative engineers and scientists look years ahead, projecting their thinking into terms of what a decade or two industriously devoted to research will bring. They see vast concepts of world-ranging rocket power, developments which now may seem only fantasy in the Sunday comic strips. So alluring and strategically bedazzling are these weapons, prediction makers may seem to laymen to be living in a world apart from ordinary citizens.

But make no mistake. They aren't dealing in impossibilities. Those "Buck Rogers" weapons are on their way. We are going to have them, and, if we are canny, we will make sure we have them before a possible aggressor nation can develop them.

A period of time, however, must intervene between our vision and the actuality.

It is well to project our thinking far into the future. It is well to envision what one or two decades of research and development will do to the form of our weapons. It is necessary.

We always must have far-flung goals to stimulate our approaches to current problems and to provide a backlog of fundamental research upon which to base those current approaches.

Nevertheless, the problems of research and development of the Army Air Forces are twofold. Fully as important as the business of lifting our eyes to the stars is the necessity of keeping our current materiel of combat at the top of the heap today—and tomorrow—and the next day; to make sure we have what is best of what is currently possible to build.

The United States must have year-to-year, day-by-day—even moment-to-moment—security.

Never again will time be on our side. Never again can we hope to prepare for war after it begins. We must be prepared before it happens. That means being prepared always, every hour of the day and night.

POBOT WAR ENVISIONED

It is entirely probable a future war, if it should come a decade hence, will be an air war, much of it fought without pilots, a nightmarish mélange of rockets and other air weapons. Each of these rockets will pack the destruction of a city within its streamlined warhead. Each will have world range, extreme accuracy, and will hurtle through the ionosphere at supersonic speeds.

This view is backed by some of the finest minds in the scientific world today.

Such a deadly prospect calls for the utmost in national cooperation and effort in research and development. No longer is the nation's research and development program unimportant enough to involve only a small segment of its resources.

Because of the tremendous impetus given technological developments by the recent war, research and development effort today is a national problem. It demands the best and most efficient utilization of every national resource and facility. Our day-to-day security demands that.

AIR TECHNICAL SERVICE COMMAND A FOCAL POINT OF RESEARCH

The center of the applied research and development effort by the Army Air Forces is the Air Technical Service Command at Wright Field. Upon this organization, the largest in the AAF, falls a gigantic responsibility, particularly in view of new concepts of warfare brought about by our present acquaintance with supersonic speeds and development of futuristic pilotless aircraft.

Pending a possible next war and to help prevent such wars, there must be enormous amounts of research and development leading to great increases in the speed, range, carrying and striking capacities of piloted aircraft and air weapons. That again brings up the merit of considering what might be called interim safety, that day-by-day, moment-to-moment preparedness.

We are on the threshold of the supersonic-speed era. Our future development, unfortunately, cannot be a steady comforting progress through fields already well-charted, as was the case in lifting aircraft speeds from 200 to 300 mph, or even from 400 to 500 mph.

The transition from subsonic to high supersonic speed provides a more ferocious dragon for the venturesome explorer in aerodynamics than ever a spinner of fairy tales dreamed up: Compressibility and its death-dealing slave, the shock wave.

THE DREADED SHOCK WAVE

The late Major Fred Borsodi of the Air Technical Service Command was the first man ever to report seeing with his own eyes during flight that dread compressibility effect. He first witnessed this phenomenon while diving his P-51D airplane over Wright Field at speeds above 600 mph.

Other Wright Field test pilots arched their eyebrows at his tale and suggested Borsodi take a 10-day rest. He did—but he came back and proved his contention by photographing the shock wave as it rode back over his airplane's wing.

The shock wave encountered in high-speed flight at high altitudes is a thin layer of air in which there is a very rapid increase in pressure. It forms only when air passes over a surface such as an airfoil at, or in excess of, the speed of sound. The speed of sound is approximately 750 mph at standard sea-level conditions of atmosphere, but reduces to about 660 mph at 35,000 ft above sea level.

The speed range in which the shock wave is formed is known as the compressibility region. Our engineers dub this general region the "supercritical" speed zone, and that particular por-

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tion of the supercritical zone in the vicinity of the speed of sound as the "transonic" region.

Although shock waves, similar to bow waves on a boat, always form at, or in front of, the nose of any object moving at a speed greater than the speed of sound, they also can form at the thickest part of the wing, at points of excessive curvature in the surfaces, such as the wing fuselage juncture, or over other parts where the local velocity is sonic or supersonic, on an airplane moving at subsonic speed.

It depends upon the value of the airplane's Mach number. Mach number is the ratio of aircraft speed to the speed of sound.

In such cases, although the airplane is passing through the air at less than the speed of sound, air flowing over the curved top surface of the wing may exceed sonic speed. This creates conditions required for formation of the shock wave.

When a shock wave is produced at a subsonic airplane speed, the air separates from the surface of the wing, instead of flowing smoothly. If this turbulent air strikes the tail, it will cause buffeting of the control surfaces, particularly the stabilizer and elevators. At the same time, the lift of the wing will be greatly decreased, affecting the plane's stability in a manner equivalent to shifting the center of gravity far forward. This makes the ship "nose-heavy," and makes "pullouts" difficult.

The shock wave, potentially a man-killer and plane destroyer, is a major problem. Its proper treatment must be solved if research and development are to achieve the goals set for them.

Perhaps these subsonic compressibility difficulties will not play too great a part in the development of those "Buck Rogers" pilotless aircraft and air weapons. Perhaps such craft can be boosted by rockets through this subsonic compressibility region into the supersonic region, where smooth flight again is attained. This boost, applied to a proper configuration, may be so rapid through the subsonic and transonic range that the subsonic compressibility effects will not be serious.

But what of the interim, when piloted craft will be our chief means of offense and defense?

Would this acceleration produced by booster rockets render a pilot helpless? If it would, what is the answer to this dragon of compressibility?

SWEPT-BACK WINGS MAY SOLVE COMPRESSIBILITY PROBLEM

Such questions are within the province of the aerodynamist and aeromedic. Many aerodynamic specialists believe they have the answer to compressibility in swept-back wings.

Approaching the subject simply, possibly at the expense of the fundamentals involved, let us suppose a stream of a certain velocity and a string of a certain strength. If we place that string at right angles across the stream's course, particles will pile up pressure and snap the cord. But if we sweep back or incline the string at an angle, less than 90 deg, to the stream's velocity, particles will slide off without building up pressure and the string will hold fast.

The swept-wing principle essentially states that the mean flow approaching a two-dimensional wing section may be split into two components, one parallel and the other perpendicular to the wing's leading edge. Only the latter component affects the basic airfoil characteristics while the former remains at constant pressure along the chord. If this premise is correct, it now is possible to maintain effectively subcritical flow over an airfoil while the Mach number of the stream is relatively high, merely by providing sufficient sweep, preferably sweepback.

It is theoretically possible, with the proper amount of sweep, to increase the critical Mach number of wings and tail surfaces to values greater than 1. The excessive increase in drag normally associated with exceeding the critical Mach number on the wing surface will be postponed. It has been suggested that sweeping the maximum width stations of the horizontal plane sections of the fuselage may be applied to the fuselage to increase the critical speed in approximately the same manner as sweep is applied to airfoils to increase their critical speeds.

Since there will be no shock waves on the wing and tail surfaces, the control surfaces will retain their effectiveness to a higher Mach number than would be possible without sweepback and be free of many of the major difficulties caused by the presence of flow shock waves.

Other compressibility effects, such as loss of lift, change in angle of attack for zero lift, and change in pitching moment, which result with the initial appearance of shock waves on the upper surfaces of the wing, also can be postponed by sweepback and by reducing the section thickness.

It is possible also to use so-called standard low-speed airfoil sections which need not be extremely thin, even at high Mach numbers. This will tend to solve landing difficulties which had been expected to occur in high-Mach-number airplanes having airfoils with sharp leading edges. Conventional high-lift devices, such as flaps, may be used also, but landing speeds may be expected to rise sharply with the angle of sweep.

It will be possible to fly at supersonic speeds, aerodynamists believe, with considerably less drag than was previously thought possible, simply because with sufficient sweep the detrimental effects of compressibility and shock waves on the aircraft will be minimized.

There will be unavoidable detached bow waves emanating from the upstream corners of both wing and tail, as well as from the fuselage. A swept-back wing, in which the leading edge of the root chord coincides with the front of the aircraft, will combine the bow waves from the fuselage and wing. Furthermore, all-wing configurations will of course eliminate tail-surface shocks.

But compressibility is only one of the many problems facing the Air Technical Service Command in the development of supersonic aircraft. There are many facets to this nightmare for research and development—propulsion, materials, electronics, armament, aeromedicine, and many others.

Since jet propulsion burst so dramatically upon the aviation scene in the midst of war, many persons have been muttering, "Propellers are on their way out." They may be right, but some persons don't think so.

PROPULSION PROBLEMS AT SUPERSONIC SPEEDS

The suitability of a propeller as a propulsive device is best expressed in terms of its propulsive efficiency. The conventional propeller on current airplanes of all types is a remarkably satisfactory mechanism. It maintains propulsive efficiencies over most operation ranges at approximate values of 70 to 93 per cent.

While the conventional propeller suffers appreciable loss in efficiency due to compressibility at speeds in excess of 575 mph, new ideas in aerodynamic design indicate propellers of high efficiency can be designed for aircraft operating in the transonic- and supersonic-velocity ranges.

Here the swept-back design is suggested again: Propellers of a swept-back design probably will be used in the transonic range.

The basic idea of the swept-back propeller blade is this: Only that component of the tip velocity normal to the leading edge contributes to the compressibility losses encountered at high tip speeds. Thus by sweeping back the blades of the propellers operating at supercritical tip speeds, it is possible to reduce the drag of the blade. This will improve the propeller's efficiency.

Latest available airfoil data indicate satisfactory propulsive

efficiencies in the supersonic zone could be obtained from propellers operating at tip speeds of 2 times the speed of sound. This would permit use of high-speed props. It is estimated propellers of approximately 6 ft diam and having eight blades could efficiently absorb about 8000 hp by turning at 8000 rpm. Of course there are attending structural problems too.

As matters stand now, propeller engineers of the Air Technical Service Command believe that if the conditions of operation warrant the use of wings to support the aircraft, then suitable propellers of reasonable efficiency can be designed for it. Propellers are not obsolete yet, jet propulsion or no jet propulsion.

However, we need some force with which to turn those propellers, or some propulsive force making the use of propellers unnecessary. ATSC power-plant engineers therefore will be busy on a great number of problems regardless of whether planes are propeller-driven or not.

TURBOJET AND GAS-TURBINE CONTROL PROBLEMS

Jet propulsion is in its infancy. Engineers have much to learn about this type of power plant. They must increase not only thrust, but also fuel economy for range, engine life, and the means of control.

The problem of turbojet or gas-turbine control is a tremendous one. Turbine-wheel speed and blade temperature are most critically limiting factors, since high thrust and fuel economy require operation near the limits of each. Automatic controls may rely on the parameters of these factors.

The chief problem connected with such control centers around the development of a temperature control which will sense accurately temperatures as high as 2500 F, in a gas stream approaching sonic velocity. Such control must possess an over-all response rate equal to, or faster than, the increase in blade temperatures and stresses.

There are many other problems. The factors of long life and retention of calibration are of extreme importance. Considerable emphasis also will be placed upon the design of safety devices for use as emergency controls. A probable additional refinement, i.e., some form of nozzle-area control, will be developed in order to realize better fuel economy and better control of thrust.

These controls apply to the gas-turbine-engine driving propellers, as well as to the turbojet; there will be additional controls needed for the former-type engine. ATSC engineers believe that some torque-sensing control which possesses very high accuracy will be required. Engine controls and propeller controls will have to be correlated in this new-type engine.

ADVANCES IN IGNITION SYSTEMS

Furthermore, suitable types of ignition sources for jet-propulsion engines are undergoing careful investigation, with high-tension circuits offering considerable promise.

Among the ignition sources being developed is an entirely new conception, the electronic discharge system. This system will offset possible spark-plug fouling troubles. Like the low-tension high-frequency ignition systems being developed for reciprocating engines, these electronic discharge circuits impress the sparking voltage at a sufficiently high value to prevent significant electrical leakage.

New experimental ignition circuits for reciprocating engines employing low voltage and high frequency are being developed. These circuits potentially are capable of operating for complete engine-overhaul periods without spark-plug replacements. Early in the war the AAF changed plugs as often as each 25 hours. Periods of 500 to 700 hours between changes are possible in the future.

The significant merits of low-tension high-frequency systems are generation with minimum energy and utilization of a type of spark relatively unaffected by electrical leakage.

NEW FUELS REQUIRED

Fuels, too, will continue to occupy the attention of power-plant engineers, for special fuels will play a big role in attaining supersonic speeds. In reciprocating engines, for example, the possibilities of using fuels possessing higher antiknock ratings must be explored still more. Techniques and processes for producing such fuels in quantity will be determined.

In lieu of such fuels in the war just past, ATSC made water and nitrous-oxide injection pay big dividends. By the use of water or water and nitrous-oxide injection, the R-2800 engine, which had a normal output of 2000 hp, was run with safety at 3000 hp.

This engine, using water injection alone in the P-47, developed 2650 hp and gave the P-47 fighter its needed edge over the German's Focke-Wulf 190.

Development of better fuels for turbojet and gas-turbine engines has barely begun. Investigations to determine a means of increasing combustion efficiency by improved combustion-chamber design and by proper selection of fuel characteristics will be prosecuted.

It will also be necessary to develop fuels to improve the performance characteristics of intermittent- and ram-jet engines.

Those are a few, a very few, of the specific problems facing engineers of the Air Technical Service Command. There are hundreds of others; specific problems dealing with ceramics for engine use, fuel-metering systems for high-efficiency engines, staggered fuselages employing the swept-wing principle to the entire fuselage, better and bigger guns, physiological problems relating to human ability to withstand the flights of the future; all these are factors in an extremely large general picture.

STRATEGY OF A FUTURE AIR WAR

Strategy and the operations of a future war are pictured on a still larger canvas. We have progressed in the art of war from stone, to club, to spear, to the battle of Hastings where massed and mobile archers proved the long bow more than a match for the cumbersome armored knights with their swords and lances.

World War I brought the airplane into combat—the piloted airplane. World War II developed the role of the piloted airplane and introduced a weapon which appears to offer even more fantastic possibilities—the pilotless aircraft, or robot carrier of destruction.

This mechanical monster is familiarly exemplified by the German V-1 or buzz bomb which was so destructive of London, and by the German V-2 rocket which is a clear hint of the future.

In May, 1945, a group of the top technicians of ATSC conferred on the future of warfare. This was their consensus:

A future war will spring suddenly, opening with massive showers of pilotless aircraft upon the victim nation's strategic cities and installations. Each of these missiles, flying at fantastic supersonic speed, will have striking power sufficient to obliterate entire cities and will be accurate within $\frac{1}{2}$ mile. Furthermore, they can be launched from any spot in the world and hit any other spot. They will operate in the ionosphere.

That will be the first wave. Shortly thereafter, when the bulk of the enemy installations and cities has been destroyed, the second wave, consisting of long-range giant bombers, will roar overhead. These bombers, carrying giantic loads of atomic bombs, will mop up any effective resistance cores, either military or industrial.

The bombers will have 10,000-mile operational ranges and will carry many times the bomb loads now accommodated. Complementary fighters of the era will have 1000-mph speeds and enormously increased ranges.

The third wave will be fleets of air transports—fleets large enough to transport entire armies, not just divisions, and deposit them at will.

War, these hard-minded engineers decided, probably would be over in one week, even to occupation of conquered territory.

This thesis has been expounded ably and publicly by General Arnold and other wise and prophetic leaders. It has slowly begun to dawn upon the American people that the past conflict may, indeed, be the last war in which pilots will play the leading role. The first intimation we may have of a new onslaught will be rockets landing in New York City, in Chicago, or in New Orleans. Lending point to this entire prophetic situation was the unleashing of atomic energy. That energy, one day, may be the propulsive force which will carry rockets around the world at fantastic heights and speeds, and provide the explosive power to climax its breath-taking trip.

The problems of controls for these futuristic missiles of ruin are vitally important. It is quite evident that any progress made in the development of high-speed high-altitude long-range aircraft, either piloted or pilotless, will be of little value unless parallel and supporting progress is made in radio and radar control equipment.

RADIO AND RADAR RESEARCH MUST CONTINUE

Recent advances in the conventional aircraft, and aircraft used as guided missles, call for drastic changes in existing radio and radar designs. With still more advanced types of aircraft destined for the atomic age, it is increasingly important to continue radio and radar research into many fundamentals. They include wave propagation, techniques for generating frequencies in the microwave region, low-loss dielectric materials, antenna and radome design to reduce aerodynamic drag, and subminiature tubes and components.

Specifically, this means that in the comparatively near future, the Army Air Forces must look to the development of equipment for tracking and controlling missiles which may travel at speeds exceeding 3600 mph and at altitudes over 60 miles. Furthermore, we must provide enough accuracy to destroy targets at any point in the world.

It won't be long before flights exceeding 10,000 miles may be possible. This means electronics engineers of the Air Technical Service Command must see to providing long-range radio and radar navigation facilities 10 times the range and essentially free of the limitations of existing equipment.

A great amount of effort must be expended in the design of smaller and lighter radio and radar components. Weight reduction has become increasingly important.

Recent developments in subminiature tubes, which make possible the use of small lightweight subassemblies, will be the basis for this work.

Basic research experiments must be conducted to obtain higher-quality insulating and dielectric materials, which will reduce attenuation at microwave frequencies and still withstand the high temperatures air friction will cause in a missile traveling at high speed.

New methods for sealing and pressurizing missiles for extreme-high-altitude operation should be developed at the same time.

OPERATIONAL IMPROVEMENTS NEEDED

ATSC engineers feel that increased air travel and the advent of even larger formations of fighters and troop carriers call for the best facilities of all-weather flying, traffic control, and weather prediction. Landing systems, for instance, must be developed to the point of handling in excess of one aircraft each minute.

Just one specific example should drive home the vast scope of the work ahead.

Pilotless aircraft will not be an American monopoly. What is possible for us to devise and construct must be considered possible for all nations. Nor are pilotless aircraft to be considered only an offensive weapon.

If some future aggressor launches against the United States a rain of supersonic pilotless aircraft as guided missiles, these missiles will certainly have relatively the same performance capacity as Germany's V-2 rocket, and probably considerably greater capacities.

This means they will be coming at us at an approximate speed of 3600 mph at about 60 to 70 miles up.

Now, defense against this attack poses two problems:

(1) The missile must be detected.

(2) It must be destroyed before it can accomplish its mission.

Such an attack makes mandatory an early warning system, possibly radar of one type or another. Suppose that the radar is about like the current systems and can detect such missiles about 100 miles away.

That means that the defense has about 100 sec to know what is coming and to get some means of counter destruction in the air to a given point of intersection.

It is now evident that we have many problems to solve. We have indicated only a few of the multitude of jobs on which we must excel in order to keep America strong and secure. The task is one of first importance and involves the full co-operation and efficient utilization of the responsible government agencies, American industry, technical institutions, and scientific groups. Our resources in scientific talent and research and development facilities cannot be allowed to stagnate through inactivity or poor direction. To assure the existence of this nation, these resources must be kept active in the right direction; they must be forced in a continuous, healthy growth.

Research and development within the Army Air Forces must be larger, more extensive than ever before. It cannot be done with theater stubs or cigar coupons. It's going to take cash and co-operation—plenty of both.

Research Needs of the Navy

(Continued from page 195)

tinue our ascendency in the sciences and engineering, we must place an increasing emphasis on fostering scientific study and training. It seems to me that this Society can assist greatly in such a program.

One of the most alarming deficiencies created by the war is reduction in the number of potential scientists and technical men, due to the withdrawal of some 17,000 students from scientific study to join the Armed Forces.

This deficiency not only must be made up, but the general level of scientific and technical knowledge must constantly be raised. With good men, we can expect greater scientific achievements, and therein lies the future security of the nation.

Obviously, the world is in a period of great change. We cannot see into the future with any great degree of certainty, but we can work and reduce some of this uncertainty by making as much progress as rapidly as possible in research and engineering. And remember, we can be quite sure that the atomic age will not dispense with common sense.

RESEARCH NEEDS *in* SUBSISTENCE *and* PERSONAL EQUIPMENT

By COL. WILLIAM H. McLEAN

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ARMY regulations assign to Ordnance responsibility for weapons, munitions, and vehicles; to Signal Corps, communications; to Chemical Warfare, gases, smokes, and pyrotechnics; to Engineers, construction; and to the Surgeon General, the care of the sick and wounded, and the general health of troops. The Quartermaster Corps has the specific assignments of petroleum products, food, and clothing and, in addition, everything not specifically assigned to one of the other technical services. As will immediately be realized, this involves a tremendous number of items, at the present time exceeding 70,000 individual pieces of equipment.

GENERAL STORE FOR THE ARMY

As a homely comparison, the Quartermaster General takes over the duties of the proprietor of a country general store. Unfortunately, however, too many people have looked on Quartermaster Corps items with the same approach as the proprietor of the country general store. After all has not man consumed food and worn clothing from the beginning of time? Why then is there any technical problem or any need for research? Why cannot we merely take products off the commercial shelves and distribute them to troops in the field? A widespread recognition of the true answer to this question will undoubtedly be the greatest single contribution to the research problem ofthe Quartermaster General in years to come.

It is perhaps inevitable that the major share of the interest given to war materiel should be confined, almost exclusively, to the offensive weapons of the land, sea, and air forces, and to the many new and startling developments in such fields as aviation and electronics. To most people, including scientists, there is nothing glamorous in a better pair of shoes, a better fabric for a field jacket, a better filling material for sleeping bags. It is much easier for us, not only in war but in peacetime, to become excited over things that make noise and smoke, which see through fog, or which propel us through the air at 600 mph. It was very interesting to me, however, to hear Dr. Frank Jewett, president of the National Academy of Sciences, state at a recent meeting that as the years of the war had passed, he had come to realize that the Quartermaster Corps was concerned with the most important weapon of any Army, "a healthy, well-fed, and well-equipped soldier."

If we have learned anything in this war in the fields of subsistence and personal equipment, it is the importance of the application of science and engineering to the design of items falling within these broad limits. Perhaps we can best obtain the key to the possibilities ahead by examining a few of the recent discoveries and making a guess as to where these new paths may lead.

TEXTILE RESEARCH A PROLIFIC FIELD

Let us take for a moment the field of textile research. In many ways one might characterize this field by borrowing a phrase from President Lowell of Harvard who when granting degrees in Business Administration was accustomed to characterize commerce as "the oldest of the arts and the youngest of the sciences." The textile industry may indeed be the oldest industry in which man is engaged and yet we are finding daily new knowledge through the application of every scientific tool including the X ray, the infrared and ultraviolet spectrophotometer and the electron microscope.

What we must apply next is the outlook of the mechanical engineer, whose mission in life is to convert scientific truths into useful forces as servants of man. Clothing is as good an example as any of an instance where the engineer can come to our rescue. In building a bridge material is placed in proportion to the stress, and materials are applied to take advantage of their best characteristics—concrete to absorb compressive loads, and steel tie rods to resist tensile stress. We all know that clothing does not wear out all at a uniform rate and yet we have just as much thickness of material throughout the sleeve as we have at the elbow, the knees, or the seat of the trousers. To a limited extent reinforced patches have been applied in work clothing, but the job is indeed one of patches.

Many individuals must have read of a recent textile process whereby a continuous fabric is laid down without resorting to the spinning of threads and the weaving of yarns. It is not inconceivable that some such principle will ultimately be applied to material for clothing and that we will put the most material where we need it most, either from the standpoint of wear or from the standpoint of insulation.

For the first time we are making a scientific stress analysis of tents and similar structures. We have suspended all work on tentage modifications until one of the engineering schools working under research contract will have supplied us with fundamental knowledge of stress and stress distribution so that again we can put the material where it is needed and of the type needed to resist tension or tear as the case may be.

As I will explain later, one of the most important problems faced in protecting the soldier from the elements is that of obtaining a vapor-permeable moisture-impermeable fabric. Water resistance of cotton fabrics has been greatly improved by a new concept of the mechanical effect of water on fabrics. Yarns tightly twisted and not tightly woven cannot swell when wet, and the interstices remaining permit the fabric to leak. Yarns with low twist, tightly woven, swell when wetted and effectively block the interstices, preventing a large proportion of leakage. This, in turn, has led us to a complete study, for the first time, of the nature of swelling in the cotton fiber. In conjunction with the Southern Regional Laboratories of the Department of Agriculture, we have established research projects first to develop precision techniques of measurement and then to study characteristics of swelling and the effect of such factors as cyclic wetting and drying, fiber structure, noncellulose content, finishes, and water-repellent treatment. The Textile Research Institute, on the other hand, is looking within

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the very structure of the fiber itself, examining the physics of the fiber and the molecular physics of the cellulose molecule. Until more is known of basic scientific facts we shall be founding our research program on the shifting sands of hunch and supposition.

MECHANISM OF WEAR IN FABRICS

With all the clothes and fabrics that have been worn out in the past thousands of years it would be assumed that by now man would understand the how and why of fabric abrasion and textile failure through wear. On the contrary, we have merely scratched the surface. For example, it has been found that far from being a surface phenomenon in which wear constitutes loss from the surface of the fabric, the internal rubbing of yarns and fibers against each other is an equally important factor. Accordingly, fabrics which are to resist abrasion must be designed to minimize internal friction as well as to avoid easily abraded surfaces. It may come as a surprise that at the beginning of the war the only strength characteristic actually set forth in the specification for Army uniform cloth was that it should resist a tension of 170 lb. I wonder, during this war, how many garments made from this fabric have actually failed in tension; and even where they have failed in tension, the real culprit was probably the abrasion that wore away so much of the material that there remained inadequate cross section to resist the imposed load.

BODY ARMOR OF NYLON

So much for standard clothing. Let us look for a minute at body armor. Everybody knows that armor should be made of steel. At least that is what everybody used to know. Now the standard Army armored vest is made of nylon with a small amount of aluminum, and the Navy, near the end of the war, provided crews of landing barges with armored panels which were entirely nonmetallic and yet which were demonstrated by proving-ground tests to be more effective than an equivalent weight of Hadfield manganese steel. How did we come to this? By study of the mechanism of energy absorption. Research in the use of these new materials has really just begun, and the years ahead will undoubtedly bring about further revolutionary changes in our conception of body-armor design.

QMC TROPICAL DETERIORATION LABORATORY ESTABLISHED

Another subject of major importance is that of deterioration. If you or I find that our awnings have rotted, we merely go to the corner store and purchase new ones. When a soldier in the tropics finds that his equipment has rotted he must call for help on a supply line which reaches 10,000 miles through depots and subdepots and in time of war places additional load on already scarce shipping. Such is the result of deterioration of a single item. The deterioration of many items might conceivably halt a campaign itself. Recognition of the importance of this subject led, in 1944, to the establishment of the QMC Tropical Deterioration Laboratory.

Originally the emphasis was on the identification, isolation, and study of the various fungi discovered on Quartermaster equipment with a view to perfecting fungicidal treatments. It may be interesting to know that over 1000 individual cultures have been separated and are now stored in test tubes in our laboratory to serve as the basis for future research. The next phase was the study of the activities and behavior of these organisms in relation to deterioration. Information of great value has been derived which has led already to the application of fungicides of greatly increased effectiveness. But we have found information of much broader significance from these studies which promises to open up entirely new fields of textile research and textile-product development.

Through a study of the mechanism by which the fungi attack the cellulose molecule, we have gained a better understanding of that molecule and of the weak points in the chain. If we can block off those weak points, for example, by partial esterification, we will protect not only against fungi but undoubtedly against many other deteriorative processes as well. This applies not only to deterioration in the field, but to the weakening of fibers during the finishing processes common in the textile industry.

LABORATORY TO STUDY MAN'S PHYSIOLOGICAL NEEDS

In order to provide the clothing and equipment designers with fundamental information, the Quartermaster Corps has established and is expanding in the postwar era a basic laboratory for investigation of physiology and the environmental protection of man. In the study of the greatest engineering mechanism of all, the human body, we are finding out daily new facts, many of which upset our preconceived notions. How many realize that under hot humid conditions we may give off as much as two liters of sweat per hr? The interaction of clothing on this process of perspiration may be of major importance in solving the problem of heat prostration. Even sitting in relative comfort and equilibrium, an individual gives off close to 50 g of water vapor per hr! If the process of evaporation is unduly accelerated, one feels cold; under similar conditions the soldier may become a casualty.

On the other hand, if normal perspiration is not allowed to pass away, it collects in the clothing as condensed moisture and lowers the insulation value. Everyone has experienced conditions where he felt wetter from body moisture inside an impermeable raincoat than would seem possible by standing unprotected in the rain. This factor is intimately connected with one of the most serious medical problems of troops in wet-cold conditions, which is known popularly as trench foot. Heat transfer, vapor pressure, moisture-vapor transfer, K factor, latent heat, thermodynamics, common phrases in the vocabulary of the power-plant engineer, have become the very basis for scientific clothing design.

To refer briefly to another field; sterilization of water in small quantities had formerly always been accomplished by substances capable of releasing active chlorine. It was found that such treatments were not entirely effective under conditions of use when the water was contaminated with certain amoebic cysts. Iodine is a much more successful sterilizing agent in such cases, but the problem remained of finding a compound harmless to man which would still liberate active iodine in proper proportions. It will be recognized that this is an engineering problem in reaction rates and dissociation time. By approaching the problem from this standpoint, there was developed triglycine hydroperiodide which in turn promises to serve as the foundation for a new approach to this most important problem in maintaining the health of troops in the field.

DEVELOPING A SOUND FOOD PROGRAM

Let me say just a word about subsistence. Modern Army research in subsistence dates from the start of the World War II emergency period. No adequate Army program of food research had been instituted after World War I and, as a result, outmoded conceptions of Army feeding still persisted.

What is the objective of a sound food program? A ration nutritionally adequate in every respect, with minimum weight and bulk, and yet designed so that the soldier will neither reject an essential portion as unpalatable nor feel unsatisfied from a belly-filling standpoint.

Long-time storage, high temperatures, moisture transfer, all multiply manyfold the problems of spoilage familiar in normal

civilian life. For example, bread is a most desirable component of the ration not only from a nutritional but also from a morale standpoint. Bread is now one item in the latest combat ration, which ration may often have to be stored for a year or two. If the product of a commercial bakery remained on its shelves for over a year, the concern would be bankrupt long before the company chemist could write his first treatise on starch retrogradation.

The Army research program in subsistence can be divided into several categories, as follows: Dehydrated products; proteins, fats and oils, starches; microbiology, bacteriology, nutrition, and food acceptance.

The shelf life of powdered eggs, powdered milk, dehydrated fruits and vegetables is not adequate for military purposes. One of the factors responsible for deteriorative changes known to occur is the reaction between the amine groups of proteins and the free aldehyde groups, such as are present in glucose. In a relatively short time the products darken, become off-flavored, and develop an undesirable texture, especially on storage at elevated temperatures. It is one objective of the program to determine the nature of this and other reactions and to establish methods for their control.

The shelf life of many fat and oil products and the fat fractions of the various food products are not adequate for military purposes. Several types of deterioration are known to occur, but the precise nature of each is obscure. It is the objective likewise of the fats and oils program to determine the nature of the deteriorations and methods for their control.

Investigations are under way for studying microbiology of fruits so as to prevent or minimize yeast sugaring in such products as prunes. Canned bacon and smoked meats require exceptional processing to destroy or inhibit microorganisms. This seriously impairs the acceptability of the products, and it is therefore necessary to determine other methods whereby microorganismal activity can be minimized without impairing the acceptability of the finished product.

Eviscerated poultry has advantages for use by the Army in that it saves time, space, containers, and refrigeration. There has been an insufficient amount of work done on evisceration practices as they influence the bacteriological condition of the finished product. This is an important consideration in its keeping quality particularly when held at temperatures above freezing. It is the objective of the poultry projects to study the sanitation practices in the evisceration of poultry and to establish optimum conditions to the end that a product with better keeping quality can be obtained. Similarly, preliminary investigations have indicated that it is possible to flash-heat liquid egg in a manner similar to the pasteurization technique employed for liquid milk. The development of thermal death-rate data for various pathogenic organisms will serve as a basis for eliminating potential public-health hazards for egg products.

The acceptability which controls the composition of overseas rations is determined to a large degree by psychological and physiological factors which have not previously been the basis of a systematic investigation. In order to design rations that will not become rapidly monotonous, that will have morale value, and that will conform to general food habits, a research program has been instituted to cover two phases, as follows:

1 It is the objective of the psychological phase to develop panel and other methods for determining in advance the acceptability of specific food items and rations.

As a further basis for ration design, it is necessary to conduct population studies for food preference, consumption rates, preference ranges, food habits, and food pattern.

2 In the second area, the physiology of appetite is being investigated from the standpoint of the effect of carbohydrate and polysaccharide-containing items, appetite depressants, environment, spices and condiments, and different types of food.

Global warfare requires living and fighting under extremely variable environmental conditions. The physical demands in many instances lead to extreme exhaustion. Human nutritional needs have not been adequately investigated as they apply to the conditions encountered in modern warfare. It is the objective of the nutrition program to investigate the effect of environment on nutritional requirements as encountered under assault, combat, survival, and support conditions. In addition, losses or changes in nutrient values of rations after storage will be investigated as well as the evaluation of synthetic versus natural sources of vitamins and other nutrients.

This entire program of subsistence research will be carried out jointly by academic institutions, by industry, and by Quartermaster Corps personnel. In every case, however, the application and reduction to practice must rely on the assistance and wholehearted co-operation of industry and industrial engineers.

CONCLUSION

In summary, may I repeat what I said at the beginning concerning the technical nature of problems relating to subsistence and personal equipment. In many cases our investigations must go far beyond those required by civilian industry, but at the same time the knowledge gained by Army research can serve as a direct basis for vast improvements in the peacetime world. It is to industry that we must constantly turn for advice and guidance, and above all for personnel. Not only in time of war is this our need but equally in time of peace.

Lieutenant General Keeberger, Quartermaster of the German field armies, in an interrogation after V-E Day, made the statement that "American Research on Quartermaster equipment had gone as far or farther in four years than the German had in the ten years since 1935, when Hitler first began the expansion of the German armed forces." This statement can and should be considered as a tribute to the imagination, initiative, and perseverance of American research and production personnel, but at the same time it must be considered as a tragic commentary on the lack of foresight which forced us to jam this work into four short years with attendant inefficiency and compromise, and too often with decisions based on inadequate scientific knowledge.

Only by a sound research program, utilizing the best scientific and technical personnel available in the country, can we avoid a repetition of what took place between the two world wars. We must review this problem cold-bloodedly with great realism. At all times we must keep before us the dangers involved which are so aptly stated by General Marshall in his biennial report to the Secretary of War:

"We finish each bloody war with a feeling of acute revulsion against this savage form of human behavior, and yet on each occasion we confuse military preparedness with the causes of war and then drift almost deliberately into another catastrophe. This error of judgment was defined long ago by Washington. He proposed to endow this Nation at the outset with a policy which should have been a reasonable guarantee of our security for centuries. The cost of refusing his guidance is recorded in the sacrifice of life and in the accumulations of mountainous debts."

One secret of our success in this war has been the spirit of close co-operation between industry and the military. The greatest research need in the years to come is an active continuation of that spirit to insure a strong and well-equipped Army, while, at the same time, contributing directly to the general welfare of the nation as a whole.

ORDNANCE SUPPLY SYSTEM

IV—Ordnance Saves Money

By BRIG. GEN. E. E. MACMORLAND, U.S.A.

CHIEF, FIELD SERVICE, OFFICE OF CHIEF OF ORDNANCE, WASHINGTON, D. C.

THIS is the last of four sections of a paper discussing operation, in this country, of the Army Ordnance depot system. The three preceding sections set forth, in sequence, the problems faced by Ordnance in absorbing production from private industry: Storing, and issuing in fulfillment of combat troop demands; principles developed and applied in daily direction of storage activities; solutions to special problems applicable to specific classes of materiel. It is the purpose of this section to describe how the Storage Division fits into the organization of the depot as a whole and, in summary, evaluate the effect of management improvements discussed in this and preceding sections.

GENERAL DEPOT ORGANIZATION

Responsibility for determining what each depot will handle, from whom matériel will be received, and to whom shipments will be made lies with the Chief of Field Service. He also provides the depots with detailed procedures for the performance of certain activities. Each depot commander is responsible for properly receiving and storing all supplies shipped to him, making shipments as directed, properly maintaining plant and equipment, and effectively utilizing manpower and facilities.

Earlier sections of this paper have discussed recent developments in the dissemination of standard operating procedures for materials-handling operations. It need only be pointed out here that it is the intent to limit the degree of coverage of standardized procedures primarily to such functions as work-scheduling, materials-handling, and record-keeping. The extension of complete standardization into such fields as determination of working hours, local purchases, and matters largely affected by local conditions would not only create an expensive central administrative organization, but tend to stultify field personnel.

Fig. 20 is the basic depot organization chart, from which individual depots, because of local conditions or the assignment of special functions, are permitted certain variations. It will be noted that the depot follows accepted Army line-and-staff organization. Functions of each of the line divisions are shown on the organization chart and, in principle, comply with accepted industrial-organization practices. In operation, the Storage Division receives incoming materiel from the Transportation Division, places it in storage, and reports action taken to the Stock Control Division. Shipping is a reversal of the procedure, with instructions being received from stock control, and loaded full cars or packed LCL shipments being turned over to the Transportation Division. In performing its duties, the Storage Division calls upon the various service divisions for performance of functions indicated by their titles.

At some depots, other operating divisions are added to perform fifth-echelon repair (complete overhaul and rebuild of combat- or training-worn vehicles, artillery pieces, etc.) and spare-parts reclamation work. Operation of the Storage Division is affected by the establishment of these additional divisions to the extent that its personnel may be called upon to perform added receiving and shipping functions, and shop mechanics are used to assist in the preservation of materiel in storage.

STAFF RESPONSIBILITIES

The assignment and performance of staff functions vary sufficiently from industrial practice to merit detailed comment. However, no deviation is made from the accepted principle that true staff functions are concerned with furnishing expert advice on planning and evaluation of line results.

Because of the far-reaching effect of a serious explosion at an ammunition depot, ammunition-inspection functions (in Ordnance parlance, "surveillance") are assigned to a staff division reporting directly to the commanding officer. Personnel of this division inspect, for compliance with safety standards, ammunition received, in storage, or loaded for shipment. Findings are submitted to the commanding officer except that, in the case of emergency, orders may be issued direct by the surveillance officer, to storage personnel to stop operations and evacuate personnel, pending receipt of further instructions from the commanding officer.

Responsibility for the performance of all other staff functions is assigned to the Control Division, which combines many of the duties of industry's comptroller, budget officer, and management engineer. The commanding officer looks to this office for advice on planning and information as to the quality of the performance of operations, together with recommendations as to how lagging activities can be corrected. He also looks to the control officer for recommendations on general organizational structure as well as assignment of specific functions. Storage officers, as well as other line officers, expect the Control Division to help them improve their operations by recommending revised procedures and furnishing performance reports on their activities. In spite of the fact that depot control divisions average only $2\frac{1}{2}$ years old, with increasing frequency line personnel bring their more difficult problems to the Control Division for analysis. This is quite natural, in view of the fact that the Control Division, with no operating responsibilities, may direct its efforts, knowing that it will be free from the daily time demands made upon line personnel.

Depot Control Divisions vary greatly in size, but those that have operated most effectively in reducing total depot-operating costs have approached one control employee for each 100

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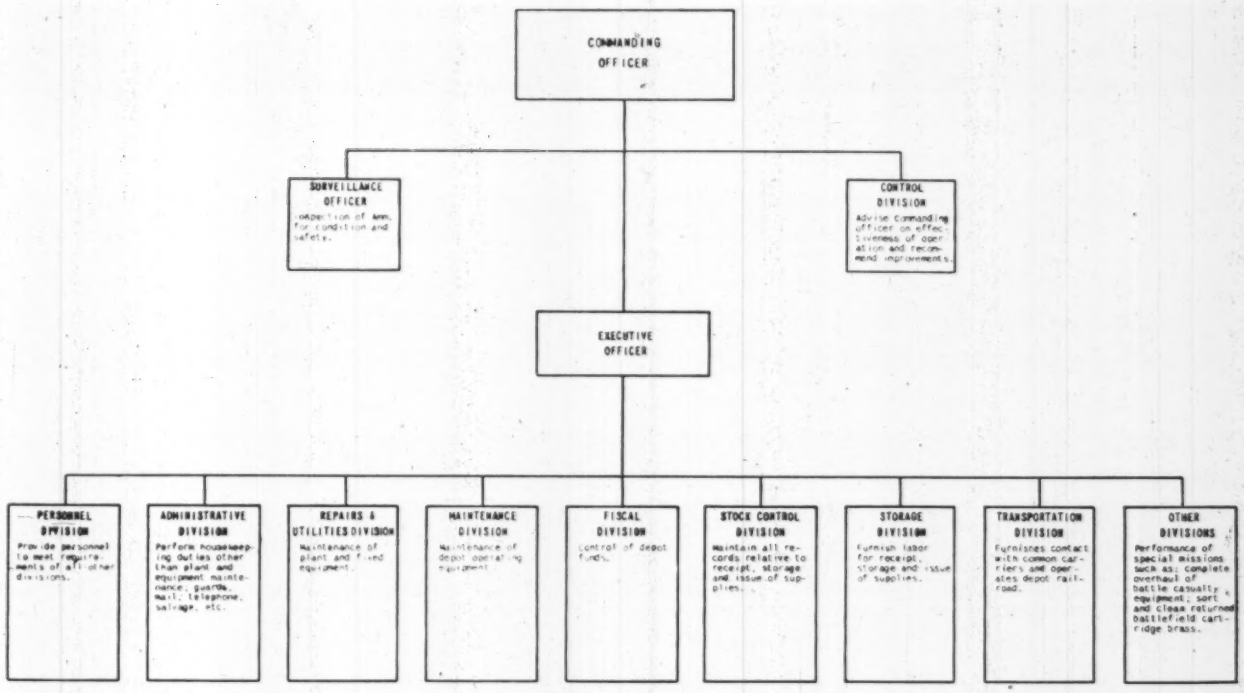

COMMANDING OFFICER
SURVEILLANCE OFFICER
Inspection of Arms for condition and safety.
CONTROL DIVISION
Advise Commanding officer on effectiveness of operation and recommend improvements.
EXECUTIVE OFFICER
PERSONNEL DIVISION
Provide personnel to meet requirements of all other divisions.
ADMINISTRATIVE DIVISION
Perform housekeeping duties other than plant and equipment maintenance; guards, mail, telephone, salvage, etc.
REPAIRS & UTILITIES DIVISION
Maintenance of plant and fixed equipment.
MAINTENANCE DIVISION
Maintenance of depot operating equipment.
FISCAL DIVISION
Control of depot funds.
STOCK CONTROL DIVISION
Maintain all records relative to receipt, storage and issue of supplies.
STORAGE DIVISION
Furnish labor for receipt, storage and issue of supplies.
TRANSPORTATION DIVISION
Furnishes contact with common carriers and operates depot railroad.
OTHER DIVISIONS
Performance of special missions such as: complete overhaul of battle casualty equipment; sort and clean returned battlefield cartridge brass.

FIG. 20 TYPICAL ORGANIZATION OF AN ORDNANCE DEPOT

depot employees. The dollar value of savings initiated by these staffs has more than compensated for their salaries. In rendering the services just described the typical control staff performs the following detail functions: It directs operation of the work-measurement (standard labor-hour) system; analyzes depot reports to determine efficiency of operations; determines the need for and prepares standard operating procedures; recommends to Office, Chief of Ordnance, improvements in standard operating procedures prescribed by that office; furnishes operating division chiefs with standard operating-procedure compliance reports; develops demobilization plans; makes procedure studies; assists the commanding officer on special planning projects.

OPERATING STANDARDS

One of the first jobs faced by control personnel when their offices were activated was the determination of adequate standards of operating performance in the Storage Division, for both periodic evaluation and daily work scheduling. The use of time studies, industry's basic approach to this problem, has long been denied by restrictive clauses in Federal appropriation acts. Accordingly, it was necessary to develop a new technique which would give required information.

Fig. 21 illustrates the production data sheet used at all depots for gathering information concerning various operations. Designed for use primarily on materials-handling jobs, it is also used for obtaining data on administrative work. Experience indicates that adequate results can be obtained from this type of form which provides for determining how long it takes an average crew to perform a given job under existing operating conditions.

Control personnel are responsible for execution of all production data sheets. On the job, they obtain an average day's production record of a crew consisting of no fewer than three persons. Data gathered include a brief description of the operation, a listing of equipment, and separation of observed time into productive and nonproductive categories. This approach,

ARMY SERVICE FORCES
ORDNANCE DEPARTMENT

DEPOT PRODUCTION DATA SHEET

DEPOT

1. DIVISION | 2. BRANCH | 3. SECTION

4. CREW | 5. LOCATION

6. OPERATION | 7. LENGTH OF HAUL

8. UNIT OF WORK | HANDLING DATA: 9. NO. OF UNITS PER [illegible] | 10. NO. UNITS HOLD. | 11. TOTAL TONS HOLD.

12. DESCRIPTION OF METHOD USED

13. EQUIPMENT

FORK LIFT TRUCK		TRAILER, WAREHOUSE		CRANE	
ROLLER CONVEYOR (Power)		TRACTOR, WAREHOUSE		PALLETS	
PALLET JACK		SEMI-TRAILER		MISC. HAND TOOLS	
HAND TRUCK (2 wheel)		TRACTOR		WEIGH SCALES	
HAND TRUCK (4 wheel)		TRUCK		TYPEWRITER	

14. WEATHER

NUMBER OF PERSONS (15)	TIME START (16)	TIME STOP (17)	TIME ELAPSED TIME (18)	PRODUCTIVE MAN-MINUTES (19)	NON-PRODUCTIVE MAN-MINUTES (20)	21. EXPLANATIONS
22. TOTAL:						

23. UNIT OF MEASURE

24. PRODUCTIVE MINUTES PER UNIT OF MEASURE | 25. CODE NUMBER

APPROVED BY: DATE | SIGNATURE

PREPARED BY: DATE | SIGNATURE

FIG. 21 FORM USED TO RECORD INFORMATION FOR SETTING PERFORMANCE STANDARDS

6-1-45 ORDNANCE FIELD SERVICE DIRECTIVES 3A1.93

Act. No. 500
Op. No. 750
Sub-Op. No. 771

Time Reporting Code	Title
771	Shipping—Ammunition—Other than LCL

Sub-operation Definition: Includes movement from storage, renovation, or packing point to common carrier; setting up at storage point and loading dock; moving from intermediate point to common carrier and loading for shipment; placing dunnage and bracing and blocking cars; clean-up of operating point; delivery of crews to operating points, if travel is paid for; driving crew to rest houses; incidental shipping band tightening; delivery of fork lift trucks, dunnage and special tools if performed by regular crew truck when on the way to or from the job.

Excludes inspection of ammunition; movement of crew on personal time; checkers and tally clerks; renovation, boxing, staining; stenciling; replace shipping bands; add grommets; bundling; repacking; linking and belting; unloading from truck into, or onto truck out of, intermediate point, such as renovation, packing and crating, etc.

Prod. Reporting Code	Work Unit	*Standard Man-hours*
	(1) Ton handled—Cylindrical—Direct:	
771-11	0 to 99 pound units	0.82
771-13	100 to 799 pound units	0.55
771-15	800 pound units and over	0.43
	(2) Ton handled—Cylindrical—Indirect:	
771-21	0 to 99 pound units	1.46
771-23	100 to 799 pound units	1.00
771-25	800 pound units and over	0.58
	(3) Ton handled—Other than cylindrical—Direct:	
771-51	71 to 120 pound units	0.53
771-53	All other units	0.77
	(4) Ton handled—Other than cylindrical—Indirect:	
771-61	71 to 120 pound units	0.95
771-63	All other units	1.09
771-81	(5) Ton handled—Brass	1.33

Work Unit Definition: (1) and (3) Total tons handled direct to car in which shipped without intermediate loading into truck or trailer.

(2) and (4) Total tons handled indirect to car in which shipped with intermediate loading into truck or trailer.

(5) Total tons of brass shipped from storage or from processing, popping or reclamation operation

Comments: This sub-operation covers labor, equipment operators and working foremen; shipping mixed ammunition and ammunition packing materials will be included in the appropriate weight groups under "Other than cylindrical"; "cylindrical" ammunition is that ammunition shipped unpalletized, cylindrical in shape, such as bombs, separate loading projectiles, propelling charges and single-round packs of artillery ammunition.

FIG. 22 CODE SHEET AND PERFORMANCE STANDARDS FORMING THE BASIS FOR ORDNANCE DEPOT WORK-MEASUREMENT REPORTING

when carefully explained to operating personnel in advance, has been accepted without question by the labor crew concerned. In addition to gathering data for standards of performance, the skilled observer uses the back of the form for a process chart of the operation, together with notes of possible improvements. These, then, form the basis for further analysis toward improvement of methods.

Performance standards derived from this type of record do not reflect a goal for the performance of a specific job. Rather, they reflect the average time required, and are therefore available without adjustment for daily scheduling of operations. Through careful selection of elements to be included, or excluded from productive time reported on the study, adequate allowance is made in the resulting standard, for the following: Travel to and from job; setup; rest periods; personnel requirements; equipment servicing.

As described in the second section of this paper, there has been installed recently in all depots a standardized daily-work-scheduling procedure. A feature of this procedure is a job work order. Information appearing thereon can be substituted for production data sheets for the majority of the materials-handling jobs.

Copies of early production data sheets were sent to Washington, where results of like operations were summarized and published for the information of all depots. Variances between depots by as much as 100 per cent of time for performance of similar operations were discovered and opened the eyes of storage officers to the possibility of developing new methods.

At that time (summer, 1943) Ordnance field service suffered from two ailments not generally faced by private industry—lack of competition and lack of a profit-and-loss statement which would furnish regular recurring checks on costs, both on an over-all basis and for comparisons of performance between various field installations. All comparisons to date had been on a tons per man-day basis, which forms a satisfactory basis for comparison only under certain limited conditions, including the following:

1 Identical mixtures of tonnage-handling characteristics.
2 Identical plant facilities.
3 Similar daily load-variation characteristics.
4 Performance of no nonstorage functions.

To furnish a more flexible basis of comparison, research was started which resulted, in the spring of 1944, in the depot work-measurement system, which compares actual labor hours with standard labor hours. Its functioning is presented in detail here because of its marked success in Army operation[3] through presenting a picture of effectiveness of manpower utilization.

Design of the work-measurement system was predicated on five conditions as follows:

1 *Condition.* Time has a universal standard interpretation.

Comment. Pay rates vary, both regionally for several installations, and over a period of time, for any one installation. An hour is universally interpreted as containing 60 standard minutes.

2 *Condition.* Reporting must start at the point where work is performed.

Comment. Performance reporting at a level higher than the first echelon of supervision frequently results in omission or distortion of data. Foreman reporting tends to minimize this error. It may be argued that labor supervision is not capable of accurate time or production reporting, but it must be recalled that pay-roll errors seldom pass the worker.

3 *Condition.* Unless the supply of required operating equipment is denied, results of operations can be directly compared if designed to produce the same result.

Comment. If two foremen, producing the same end product, operate with different procedures, their performance may be directly compared, providing identical plant and equipment are available to each.

4 *Condition.* Satisfactory results can be obtained from reasonable standards.

Comment. For top management use, standards should not be revised each time an improvement is made in a procedure. If such were done, standards originally set on theoretically perfect performance would soon be outmoded. Since all comparisons are made to the same level of performance in order to determine relative variance therefrom, a standard that is within the range of reasonableness will give sufficient accuracy.

5 *Condition.* Everyone wants to know what is expected of him and how well he meets those expectations.

Comment. One of the quickest ways to ruin employee morale is to deprive the worker of knowledge of "where he stands."

For record-keeping, all depot activities are codified (see Fig. 22, for typical code sheet), and each foreman daily reports expenditure of all man-hours and production obtained against each code. These reports, after being checked against clock cards, are forwarded to a central point for daily posting to recapitulation sheets. Summary reports are drawn periodically by code, totaling and multiplying reported production by standards. The resultant standard time for each code is compared with actual time expended and the ratio obtained expressed as a percentage of effectiveness for each code, as well as by total for the depot as a whole.

Summaries are prepared monthly for all codes and for individual codes at such intermediate periods as may be desired by supervisory personnel for checking troublesome operations. It is common practice within storage divisions to have weekly, and in some cases daily, summaries of each foreman's activities published to promote crew competition. Fig. 23 shows one method of displaying results obtained.

Universal standards for operation of the work-measurement system are derived in Washington from production data sheets prepared at the depots but may differ from standards used in daily scheduling of operations. Failure to recognize the necessity for a variance between these two types of standards may lead to trouble at the depot level. Work-measurement standards are set by arranging all depot production data sheets, for any particular code, in order of number of man-hours per work unit produced. The upper quartile point, which 25 per cent of the depots exceed and 75 per cent fail to meet, is selected as the standard. This results in an attainable goal.

For daily work scheduling, the work-measurement standards must be converted from man-hours per unit of production to crew-hours per unit. However, depots whose operating effectiveness differs widely from standard, either above or below, will find that actual production varies greatly from scheduled if they use the service-wide work-measurement standard for daily scheduling. In such cases, accurate scheduling can be obtained only by use of local standards for planning the daily work assignment.

Fig. 24 shows an extract from a monthly summary of work-measurement results prepared in Washington from each depot's individual summary. Man-hours expended and percentage of effectiveness are shown for each depot, by code. Information given in this manner indicates to Washington personnel spots where management assistance, in the form of visits or development of standard operating procedures, should be directed. It

FIG. 23 SOME ORDNANCE DEPOTS RATE THEIR FOREMEN EACH WEEK IN EFFECTIVENESS OF PERSONNEL UTILIZATION, POSTING RESULTS NEAR TIME CLOCKS

[3] The Army Service Forces, effective December 1, 1944, adopted basic principles of the Ordnance work-measurement system as standard throughout the entire depot system.

Form No. 88-279
(Formerly 17 Mar 1944)
SPORT
(In lieu 40)

ARMY SERVICE FORCES
ORDNANCE DEPARTMENT

COMPARISON OF FIELD SERVICE DEPOT ACTIVITIES
WORK MEASUREMENT

JUNE, 1945

	ASF - 38		ASF - 38		ASF - 39		ORD - S11		ORD - S12		ORD - S14		ASF - 41		ASF - 42		ORD - S51		ORD - S52		ASF - 43		ORD - S61		ORD - S62		ASF - 44		ORD - S91	
CODE			Unmeasured																											
DESCRIPTION	STORAGE		STORAGE		Administrative		Storage Admin. Ammunition		Storage Admin. Gen. Sup.		Master Locator Files		Bin Selecting		Checking & Tallying		Checking & Tallying Ammunition		Checking & Tallying Gen. Sup.		Cleaning		Cleaning Ammunition		Cleaning Gen. Sup.		Internal Hauling		Depot Transfer Ammunition	
DEPOT	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS	%	HOURS
Depot A	104	33393		5860	73	3680			105	1976	36	1704	113	780	56	2645			56	2546	131	2776			131	2776	149	386		
Depot B	98	332667		86966	83	31737	71	7972	103	14851	60	8914	26	5123	123	8572	81	2019	136	7665	52	25212	30	12838	76	12375	77	9888	106	1182
Depot C	79	227190		12670	54	32395			75	17303	30	15092	66	27666	97	6074			97	6074	72	9566			72	9566	95	11299	106	1102
Depot D	100	117786		9335	89	10165			144	4644	42	5521	84	4369	107	3288			107	3288	35	9937			35	9937	108	1568		
Depot E	66	20192		911	50	2510			46	2326	99	181			114	2073			114	2073	103	504			103	504				
Depot F	92	186218		24799	75	21183	80	1501	78	12014	43	7668	47	30184	82	7681	86	443	82	6138	49	10155	64	1250	47	8905	78	8319		
Depot G	89	62640		16398	88	4472	117	2508	50	1520	51	444			142	4161	74	2822	283	1339	122	2335	109	1796	134	339				
Depot H	103	156304		55061	94	12566	79	7233	166	2745	62	2588	94	1503	94	4140	38	3154	270	986	64	10945	55	6897	79	4048	128	1929	120	103
Depot I	91	29024		4600	313	601			313	601					437	2227			37	2227	50	4300			50	4300	87	1649		
Depot J	83	52247		9382	49	7835			40	7107	137	728			83	7680			83	7680	58	3707	58	3707			166	446		
Depot K	109	104340		9932	94	8164			104	5379	71	2785	179	472	145	4768	71	553	167	4215	60	5556	18	885	68	4671	194	3574		
Depot L	77	223730		2383	454	259	454	259							155	780	155	780			107	734	107	734			107	3056	107	3056
Depot M	128	15329		45827	111	2532	111	2532							162	261	162	261			112	602	112	602			109	1581	109	1581
Depot N	89	58657		17405	80	6708			84	4707	69	2001	239	1211	71	2855			71	2855	130	3165			130	3165	97	397		
Depot O	88	46595		4161	90	3027			90	3027					66	251			66	251	30	1897			30	1897	80	3754		
Depot P	89	214239		19728	45	36202			46	24941	43	9271	97	15524	63	4788			63	5788	44	14758			44	14758	194	13976		
Depot Q	97	1647		4171																										
Depot R	94	90807		7725	53	12444			92	5315	24	7129	53	8147	47	3479			57	3660	104	2827			104	2827	68	6515		
Depot S	81	405622		85537	55	53687	83	7994	63	26984	32	18709	103	22944	52	42667	55	5903	51	36764	50	24144	63	6782	46	17362	94	4380	67	1832
Depot T	95	105539		6492	66	11666			79	7199	45	4462	43	8751	93	8134			93	8134	77	6193			77	6193	70	2324		
Depot U	110	147684		13558	77	12978			89	9469	85	3509	122	10645	66	7248			66	7248	329	2781			328	2781	127	2267		
Depot V	58	51273		1458	48	7306			74	3493	24	3813	13	6378	51	3787			51	3787	40	2068			40	2068				
Depot W	86	63212		47651	51	9482	51	9482													36	8892	36	8892			85	4272	85	4272
Depot X	92	117856		6375	67	12811			76	8338	50	4473	54	11504	58	3015			58	3015	61	10468			61	10468	118	5955		

FIG. 24 EXTRACT OF SUMMARY DISTRIBUTED MONTHLY TO ALL DEPOTS TO COMPARE PERSONNEL UTILIZATION BY ACTIVITY

is also used by depot management to compare effectiveness of single operations between installations. Where one depot shows up particularly well in the performance of a certain activity, it may expect to receive visits from personnel at other depots seeking to find out what innovations have been developed.

The first year's operation of the work-measurement system, at a gross cost of $400,000, or 0.2 per cent of the total depot pay roll, has demonstrated the following benefits:

1 An index for comparing effectiveness of personnel utilization at dissimilar field installations.

2 An index for comparing man-hour cost of present with past activities, both on an over-all and an operation-by-operation basis.

3 Reliable man-hour factors for long-range planning.

In evaluating these benefits, it must be remembered that the work-measurement system, or any reporting system, is not an end in itself, but only a management tool; like any tool, it is only an expensive luxury if not used. Its benefits cannot be isolated and evaluated in terms of dollars and cents, but its use heavily contributes to the very sizable management savings shown later in this section of the paper.

OTHER MANAGEMENT AIDS

Two other management aids have been used extensively by Ordnance to promote interchange, between depot storage officers, of information concerning new handling techniques, i.e., improvement reports, and integrating committees. Each time a depot develops a new special-purpose pallet, or a new stacking pattern that saves space, or a procedure change that saves time, an improvement report, illustrated in Fig. 25, is prepared by the depot concerned and forwarded to Washing-

Form No. 88-144
SPORD
Jan 45

ARMY SERVICE FORCES
ORDNANCE DEPARTMENT

IMPROVEMENT REPORT

NOTE: See reverse side for instructions

1. INSTALLATION: Blank Ordnance Depot
2. DIVISION: Supply
3. ACTIVITY: Transporting and storing reclaimed dunnage.
4. DESCRIPTION OF ACTIVITY: Reclaimed lumber from used dunnage transported on manually operated trailers from dunnage reclamation building to lumber yard and stored for use. Trailers operated by four-man crews.
5. PERSONNEL: 16
5a. MAN-HOURS PER MONTH USED: 3,328
6. CHANGES: Three Shop Mules were procured to pull lumber trailers. Lumber trailers now loaded with uniform lengths to facilitate storage. Lumber Yard reorganized with the result that stacks of lumber now present an orderly progression with respect to the lengths which they contain. There is now a marker on each stack giving the exact length to be found.
7. METHOD OF INSTALLING:
8. RESULTS: The addition of Shop Mules for transporting Lumber trailers plus other improvements noted above has resulted in a net personnel reduction of nine men.
8a. MAN-HOURS PER MONTH SAVED: 1,872
9. EFFECTIVE DATE: 9 June 1945
10. ORIGIN (Indicate source of improvement)
a. [X] WORK SIMPLIFICATION TECHNIQUE: Informal
b. [ ] SUGGESTION SYSTEM AWARD GIVEN
c. [ ] JOB METHODS BREAKDOWN
d. [ ] OTHER

FIG. 25 WHENEVER A DEPOT DEVELOPS AN IMPROVED METHOD, IT SUBMITS A DESCRIPTION TO WASHINGTON FOR EVALUATION AND POSSIBLE GENERAL DISTRIBUTION

ton. Those ideas suitable for general application are published periodically for distribution to all depots. During the 90-day period, March through May, 1945, an intensive drive was held and improvements saving 2,500,000 man-hours per month were reported to the Chief of Ordnance by the 53 Ordnance depots, as a whole.

The depot storage officer also greatly benefits from his participation as a member of either the General Supply or Ammunition Depot Integrating Committee. Many manufacturers are familiar with Ordnance Industry Integrating Committees where representatives of various companies holding contracts for manufacture of like Ordnance items meet periodically, under the chairmanship of one of their own members, to exchange ideas on solutions to common problems. This technique has been adapted to the development of the two depot storage committees. Meetings of two days' duration are held at 90-day intervals, each at a different depot. Each meeting is attended by the depot's ammunition or general-supply storage representative, as appropriate, and is presided over by a permanent chairman elected by the group. The agenda is usually prepared by personnel on the staff of the Chief of Field Service.

Of particular interest in the operation of these committees is the fact that, of their own volition, they have appointed subcommittees to perform research on various phases of storage operations and propose standard operating procedures for general application.

Supervisor participation in the integrating committees is an indication of Ordnance's effectiveness in utilizing training staffs for wartime development of operating personnel. Ordnance had no exception to the difficulty generally experienced in obtaining adequate supervision for staffing newly constructed plants. Frequently, foremen directing activities in the storage area were farmers whose land had been procured by the Army in order to build the depot. In most cases, the native intelligence of such men (and women) was found to be excellent, but lack of industrial experience was a serious handicap to the rapid development of an efficiently operating organization.

To meet the training problem, small staffs of experts in this field were developed in the Personnel Division of each depot. The actual instruction of individual foremen, however, was performed by supervisors selected by their operating division chiefs and trained to become part-time teachers by the depot training staffs. In this manner, it was possible to extend both initial and follow-up job methods and work-simplification instruction to 10,000 foremen and gang bosses through the use of only 200 training experts. Moreover, this technique developed a group of top Storage Division supervisor personnel qualified to conduct a continued program of foremen meetings and refresher training courses on standard operating procedures.

SAVINGS OBTAINED

Accurate quantitative evaluation of any individual management tool developed is not practicable, particularly when several are introduced simultaneously into an operating organization. It is for this reason that little attempt has been made in this paper to evaluate dollar savings of each of the various programs discussed. However, the effect of all improvements on the over-all material-handling cost for receiving and shipping is shown in Fig. 26.

In summary, during the period April, 1944, through March, 1945, the tons per man-day rate at which receiving and shipping personnel operated increased from 2.67 to 4.55, while average monthly tonnages handled remained relatively static. This decrease in handling cost, from $2.25 to $1.30 per ton, resulted in a saving of approximately $10,000,000 for this period. In addition to this, approximately the same amount was saved in other depot activities. This saving in wages alone, for the year preceding the surrender of Germany, the rate of which was maintained until V-J Day, is a result of Ordnance's increase in effectiveness of manpower utilization through development and application of new materials-handling and management techniques.

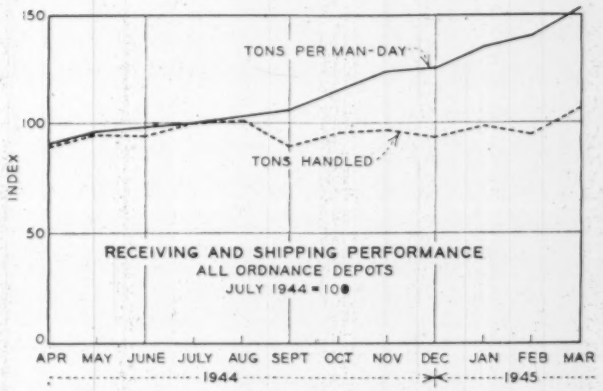


FIG. 26 ORDNANCE HAS REDUCED HANDLING COSTS WHILE TONNAGE HANDLED HAS REMAINED RELATIVELY STATIC

Research Needs for Weapons

(Continued from page 198)

until the hurdles of starting their commercial work have been passed. However, in peace, time is not so pressing as in war in the development of ordnance equipment, and funds are limited so that it would be logical if this work were undertaken on a limited basis and extended over several years to obtain the results expected under war conditions in a few months. This is our plan for approaching industry in peacetime and in endeavoring to preserve the science-industry-ordnance team.

If Congress will provide an adequate and fixed amount of money each year for ordnance research and development, it will be possible for us not only to keep abreast of foreign nations in our weapons development, but at the same time there will be considerable reward to the American taxpayer through the technological and industrial improvements which are sure to follow in the future as they have in the past.

ORDNANCE DEPARTMENT SOLICITS AID OF THE SOCIETY

This Society has always worked very closely with the Ordnance Department in peace and in war. We are now returning to that new era of peace when again we will sorely need the advice and assistance of the individual members and of the Society. We have asked the Society to set up a standing committee which will be available to receive ordnance problems pertinent to the Society's field of endeavor with the idea that this committee would be able to appoint qualified subcommittees to work on particular problems as they may be presented. Ordnance covers a very wide field and involves nearly all phases of mechanical, chemical, and electrical engineering. Our problems are varied and it is not likely that any one committee could be appointed which would satisfactorily advise in all fields of ordnance. However, when a special problem arises, it is believed that the standing committee could select for us, from the membership, qualified scientists and engineers to work on the problem. We sincerely ask for and hope to obtain the Society's full support.

Recent Developments in WOOD FINISHES

By PAUL S. KENNEDY

VICE-PRESIDENT, MURPHY FINISHING CORPORATION, NEWARK, N. J. MEMBER A.S.M.E.

THE art of wood finishing enjoyed important advancement during the period following the first world war, and there is every reason to anticipate some striking developments just ahead. The underlying reason for this is that many research laboratories are now concentrating seriously on a composite study of complete finishing systems, as contrasted with a previous policy of specialization and individual finishing products.

LACQUER FROM SMOKELESS POWDER

The first world war had a vital impact on the finishing industry which revolutionized both product performance and product development. The end of hostilities left huge supplies of smokeless powder, which were doomed to uselessness, unless some new adaptation to a useful peacetime service could be made. Research concentrated on this urgent problem of salvaging, and out of it came what is popularly known as low-viscosity nitrocellulose lacquer.

Prior to this time, nitrocellulose lacquer had been a relatively unimportant finishing material, even though it had been in use for a great many years. The fact that it was possible to dissolve but a few ounces of nitrocellulose per gallon, and still maintain a viscosity which could be applied by spray gun, restricted its employment to specialized uses where a thin film thickness was acceptable.

This new discovery for reducing the viscosity of nitrocellulose now made it possible to dissolve a sufficient quantity to produce a workable lacquer with adequate film thickness.

The first widespread commercial application was in the automobile industry. Almost immediately, two dynamic changes occurred:

1 Automobile finishing systems now required about the same number of hours that had formerly been measured in days.

2 The previous varnish systems for finishing automobiles required extensive storage space during the various drying periods. Nitrocellulose lacquer, by contrast, was an almost instantaneous air-dry finish, and Detroit body companies were immediately able to close building after building, for which they no longer had use.

Obviously, this experience of the automobile industry had nation-wide repercussions. What could be more ideal than instantaneous air dry and minimum floor space for storage?

So everybody tried lacquer, including the wood-finish industry. But with few exceptions, neither the manufacturer of finishing materials nor the consumer was prepared.

Up to this particular time laboratories had been regarded as a necessary evil in the finishing industry. Tolerated from the standpoint of raw-material and finished-product control, they were definitely discouraged from the standpoint of research and creation. In other words, the "practical paint and varnish man," together with his "secrets" was still in the saddle.

With this sudden advent of an unknown interloper in the form of lacquer, and the obvious necessity for scientific knowledge and research, he was helpless.

Came a wild scramble in the industry to set up laboratories, and staff them heavily; and looking back historically, this marked the transition period of the paint, varnish, and lacquer industry from a rule-of-thumb operation to a highly specialized arm of the chemical industry.

How about wood finish during this period of evolution?

THE DU PONT LACQUER LICENSE

Had it not been for a circumstance known as the du Pont Lacquer License, lacquer would undoubtedly have been generally abandoned as a hopeless failure for the finishing of wood. Many shortsighted people, both suppliers and consumers, first regarded this license as a holdup; to exact tribute, in the form of royalty, on the one hand; and to boost and control prices, on the other.

Factually, the movement had the backing of a group of far-seeing finish manufacturers who believed it to be the only possible means of preventing a new and promising finish from falling into disrepute. Their judgment was justified, for there was eventual and universal satisfaction and praise by suppliers and consumers alike.

Incidentally, the patents on which this license was based expired during 1944; and there is serious concern that buyers may not remember and be on their guard in this early postwar period.

There are definite indications that the same destructive merchandising methods are going to be employed by some hungry suppliers. In such event, they will undoubtedly intimidate other competition which would normally be inclined to strive for the best interests of the consumer. It should therefore now be remembered that ruthless price competition once resulted in the supply of such increasingly inferior lacquers for wood finish that costly damage claims, and the like, almost caused general abandonment of its use. At this most critical time of dissatisfaction and doubt in the wood-finish industry, the lacquer license went into effect and resulted in a complete reversal of the trend.

A "floor" selling price was calculated, which insured a modest, but fair profit. As it worked out over the years, this floor or minimum price became the actual general selling price; which made for highly desirable stabilization for both supplier and consumer. But the most important effect was that effort was concentrated on making lacquer products better, instead of cheaper. With essentially the same selling price, competition was confined to quality—upgrading, instead of degrading.

Contributed by the Wood Industries Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

IMPROVEMENT IN THE QUALITY OF LACQUER

Following the firm establishment of nitrocellulose as a dependable finish, the program of quality improvement naturally resulted in research to the end of employing new and advanced materials.

There are three basic components of a lacquer film: (1) Nitrocellulose, to give fast dry and toughness; (2) resin, to give hardness and desirable shop properties; and (3) plasticizer, to give elasticity.

The early good wood lacquers had desirable cold-check resistance but were deficient in humidity or moisture-check resistance.

Early studies revealed that this nitrocellulose-film problem must be solved through the component resin, rather than by means of plasticizer. Although plasticizers give elasticity, they do not help importantly in humidity-check resistance. Their extended use affects drying properties, and they can make films sensitive to hook and alligator checking.

Meanwhile, these newly established and very efficient laboratories had begun to come up with new synthetic resins. Of these, the so-called alkyd type became most prominent. This type of resin might be simply described as of three components. Typical of two of these components would be phthalic anhydride and glycerine. These combine to form a water-white resin which is too brittle for most uses. Hence during manufacture, a third component is added in the form of a softening agent. This might be either a fatty acid, or an oil, or a mixture of fatty acid and oil. Such fatty acids or oils may derive from drying, semidrying, or nondrying oils. Hence a wide latitude is afforded for alkyd-resin modification, to produce interesting properties.

The first all-out commercial application of this so-called synthetic combination alkyd-lacquer type of material was by one of the prominent piano manufacturers just prior to 1930. At the end of ten years their record of finish failures was confined to a few instances of most abnormal usage, whereas the previous ten years had required substantial annual charges for adjustments.

It was about 1939 that the potentialities of this resin formulation were beginning to be generally recognized in the wood-finish industry; and such lacquers were increasing in general use up to the time of our entry into the war when they were restricted for civilian production. There is every reason to believe that this development will be pursued further during peacetime; and it is in this field that we may look for improvement in lacquer finishes, provided the consumer is not deluded into false economy by judging products from the angle of package selling price only.

Also, prior to the war, the advent of the alkyd resin had provided a means of sealing wood successfully in a manner not hitherto possible. For instance, the radio industry was faced with large losses each year because of finish failure on cabinets sold for export. This applied not only to cabinets sent to tropical countries; but also to ocean shipments to temperate countries.

The same principles which had been applied to the making of alkyd synthetic lacquer were employed in the study of making sealer for these export cabinets, so that in the first year of its employment during the middle thirties, by one of the largest radio companies, export losses were promptly reduced to a minimum figure.

Further refinements were introduced up to the time of hostilities, when this development was adopted by the Government as the basis for the treatment of plywood on warplanes and gliders.

As experience proceeded, additional problems posed themselves; particularly the attack on wood by fungi and certain insects. This was coincidental and a most serious matter to the Signal Corps. Much co-operative work was done with them in the introduction of various fungicides into modifications of these sealers. Termed by the Signal Corps as "tropicalization" treatments, they are both effective and promising for peacetime exploitation.

DEVELOPING PERMANENT STAIN

This thumbnail sketch of outstanding products, adaptable to wood finish, would not be complete without the mention of another fundamental development brought out by the research laboratories in the late twenties. This was the so-called non-grain-raising or permanent stain, which now has wide acceptance. In brief, it employs exactly the same anilines or dyes in common use for staining for so many years. But instead of having to dissolve the dyes in water, a mixture of desirable organic solvents is used. The water stain had many disadvantages, which made it costly in the ultimate. It did not penetrate, but remaining on top of the wood distorted the fiber structure, raising the grain. It precipitated an excess of dry coloring matter, interfering with clarity. It put moisture back into the kiln-dried wood and frequently had serious action on the glue of joints and veneers. Finally, it was slow to dry and handle. Its greatest factor of costliness was that the grain fibers which it raised had to receive a wash coat of shellac to stiffen them for sanding before finishing could proceed.

The non-grain-raising stain not only eliminated these labor and material costs, but gave dependable drying performance. These stains penetrate deeply and deposit no excess coloring matter. Hence they not only give clarity, but enrich the development of wood figure. Techniques have been developed which make it possible to uniform widely varying wood surfaces; matching-in sap streaks and compensating for various mineral and color casts in the lumber, etc. Because of almost instantaneous drying, all of this can be consecutively and economically accomplished on the wood itself, before any other finishing materials are applied.

COMBINATION STAIN AND FILLER DESIRABLE

For some years development work has proceeded on a combination stain and filler, which employs the non-grain-raising stain as its base. While this type of product has gained limited but successful commercial adoption, it seems headed for wide exploitation in the future. It not only dries rapidly, but its composition is adapted to take top coats of what are expected to be the finishes of tomorrow.

This brings us to the subject of wood filler. Despite the fact that this is the keystone of all finishes on open-grained woods, it has been the most despised and neglected of all finish-product development. It is a typical example of the warning expressed earlier in the paper, with respect to the merchandising of lacquer.

Wood filler has been such a subject of close-margin selling that there has been no incentive for its improvement. In fact, most finish manufacturers prefer not to bother with it, and few push it. It is a glaring example of needed co-operation and encouragement between maker and consumer. In fact, if the benefits of the new and proposed types of peacetime finishes are to be availed of, it can be stated dogmatically that they cannot be used over the present orthodox type of oil-paste wood filler.

As a matter of fact, this ordinary type of filler has seriously degraded the full possibilities of many good lacquers, since they first came into common use. Hence a change of attitude on wood filler is a "must," for it can be truly stated that a wood finish is no better than the filler it is applied over.

In this connection, there is one development which will make an early peacetime appearance in production where there is no filler problem. This is the reproduction of beautiful grain effects such as crotch and fiddleback mahogany, butt walnut, satinwood, rosewood, etc., on comparatively inexpensive close-grained woods. This is accomplished by graining from plates made from photographs of unusual and selected wood flitches. The idea of such graining is not new. But apart from the unusual technical plate improvements which have been made, the inks and color-treatment coats employ the very latest in war-research development, and are quite unusual and distinctive.

A considerable amount of this product was expected to be on the market early in 1946, and great interest has been excited among those who have seen the fidelity of some of the reproductions. This will definitely be of peacetime interest because of the possibilities for beautiful and unusual finishes, and the attendant economies of shop and lumber cost.

RESEARCH CONTINUED THROUGH WAR PERIOD

This probably represents the first of the peacetime developments to go into production. Some of the others are still in the offing, mainly because it will be necessary in most cases for the technical and practical people of the supplier and consumer to work together to arrange for use.

These will include both air-dry and baking finishes, all of which tie back into the synthetic-resin research which has been proceeding during the war period. The two outstanding characteristics of these clear finishes will be higher-than-lacquer solid contents or film thickness, and improved film resistance. All will adapt themselves to short finishing schedules. In the case of air-dry types, the finish will be "out of dust" in a period comparable to that of lacquer; and the average forced dry period for the baking types will be one hour at 150 F.

As previously stated, one bottleneck for all of these types, for use on open-grained woods, will be the filler. This angle should be studied carefully and determined before proceeding with production.

The ultimate promise, however, is worth the serious investigation of all progressive wood finishers. A period of study, trial, and possible change of accustomed procedure must be anticipated.

SUMMARY

To summarize some of the possibilities of the future peacetime finish:

The first operation is treatment of the wood with non-grain-raising type of stain; both for uniforming and desired body-stain effect, as all should properly be done in the wood itself, rather than by correction of color deficiencies in the top finish coats.

The next operation for the ideal finish would be the use of synthetic sealer. Preferably applied by dipping, it can be sprayed or brushed, and any surplus should be wiped off with cloth. It has been demonstrated that the proper sealer replaces something in the wood that has been removed in its seasoning. It sets up moisture resistance, compensates for the natural tendencies of the wood itself to humidity and cold checking and splitting, and restores natural elasticity. If there is any possible hazard of tropics or insects, a suitable fungicide can be added to the sealer when applying.

In any event, wartime practice and development of waterproof glues take satisfactory care of the underside "torture" of a veneer. The sealer takes care of the topside and preserves the flexibility of the wood.

Following the application of non-grain-raising stain to open-grained wood, the next major operation is filling. Practice has developed the desirability of an optional application of a lacquer-type wash coat prior to filling. (This is not necessary if proper synthetic sealer has been used.) This optional operation makes filling easier and gives outstanding improvement in clarity and sharpness of final finish.

In case a suitable combination stain-and-filler type is used, this would be applied directly to the wood and then the synthetic sealer would be sprayed over it. If properly formulated, it will permit adequate absorption of the sealer for action on the wood.

At this point it would seem pertinent to outline the functions of a satisfactory filler.

1 It should fill pores.

2 It should give transparency and avoid muddiness.

3 It should not be affected by top coats applied over it; such as by upheaval or graying of the pores.

4 It should be a proper foundation for top coats and should definitely knit with them.

In conclusion, the outlook and success of peacetime wood-finish progress warrants the following considerations:

1 Material cost of finishing materials is usually such a minor percentage of the total cost of a finished unit that careful consideration should be given to the intangible elements, such as mileage, working properties, shop hospitalization, and particularly ultimate finish service. Just a slight difference in material package cost of a finishing material can be negated many times over by unappreciated shortcomings in the finishing room.

2 Lacquer will undoubtedly come back prominently in early peacetime production. It possesses further potential possibilities for product improvement. Whether these come to pass depends essentially on the encouragement of the consumer in exhibiting prime interest in quality. He will get what he pays for.

3 The attendant concentration of research laboratories on various synthetic resins during the war has resulted in clear finishing products of great potential possibilities for wood. The ruggedness and resistance of these finishes makes them most inviting, but their adoption for practical use is presently stymied to some extent until worthy undercoats, particularly filler, are developed.

4 The co-operation of the consumer in encouraging finish suppliers in the development of suitable fillers is most vital. This will undoubtedly call for some changes in shop practice, as the proposed new type of filler will probably require closer attention—to wiping time, in particular.

5 The possibilities of wood reproduction should be explored as sturdy construction and attractive finish, together with important economies, are indicated.

6 Particularly where production conveyer lines are being considered, the forced dry or baking type of finish offers most attractive possibilities for controlled performance, attractive appearance, and stout resistance.

7 The preliminary treatment in the wood itself should be thoroughly studied. This would involve both staining and uniforming operations; and the use of synthetic sealer, with or without fungicide.

PONTOON MANUFACTURE *in the* PACIFIC

By CAPT. H. W. RISTEEN[1] (CEC), U.S.N.R.

MUCH has been written concerning the Navy pontoon or "Seabee jeep" and the part it played in the war. However, little has been told of the units which were organized to manufacture these pontoons in factories located on various islands in the Pacific.

HISTORY OF PONTOON-MANUFACTURING PLAN

Pontoon equipment was designed for the purpose of providing various waterfront structures that could be shipped in small units and assembled at advance base locations where they were needed. These structures included barges, wharves, dry docks, causeways, tugs, and various special structures.

In the summer of 1942 it became apparent that the quantity of pontoons required would exceed the shipping space that could be made available. A study was made at once to determine whether pontoons could be shipped in the form of plate and structural-steel shapes cut to size, with the idea of manufacturing pontoons in a plant which could be erected at an advance base. The investigation showed that the shipping volume of the steel in this form was approximately one twelfth of that for an assembled pontoon. The shipping of the material in this form in combination with other advance base material, which runs about 100 cu ft to the ton, enabled the ships to be loaded to capacity in so far as both cubage and tonnage were concerned.

The initial plans called for the organization of manufacturing units to build 32 pontoons per day. Based on time studies made in various manufacturing plants in this country, a complement of 360 men per unit was decided upon. These units were only to manufacture and to deliver the finished product to an advance base or other depot for shipment to the various agencies requiring them.

At that time there were two types of pontoons, the T-6 and the T-7. The T-6 pontoon was a rectangular box-type structure, measuring 5 × 5 × 7 ft, one 5 × 7 surface being the deck. The T-7 was a 5 × 7 × 7-ft structure, with a 7 × 7 plate constituting the deck. The bilge plate of the T-7 was curved and this pontoon was designed to form the bow or stern of a barge. These are the only types of pontoons that have been made in quantity at advance base plants.

It was decided that these manufacturing units would be known as "pontoon assembly detachments," the idea being that the unit was organized to build or assemble the pontoon itself rather than the structures that could be made from pontoons. This choice of a name proved to be a mistake as various activities in the field were prone to consider the unit as a barge-assembly unit rather than a manufacturing unit. Additional complications developed later when "pontoon assembly battalions" were formed. These units did no manufacturing. Their function was to assemble pontoon structures, man pontoon-gear depots, and handle the pontoon barges and causeways in connection with amphibious landings.

[1] Head of Construction Battalion Training Department, Civil Engineer Corps Officers' School, Naval Construction Training Center, Davisville, R. I. Formerly Officer in Charge of Pontoon Assembly Detachment Number Two. Mem. A.S.M.E.

The first pontoon assembly detachment to be commissioned arrived in Noumea, New Caledonia, the middle of January, 1943. A plant and camp were erected and the first pontoon came off the line on April 1, 1943.

During August of 1943 plans were made to organize another unit for a location in the Russell Islands. This unit was put into commission and outfitted in Noumea. One hundred and fifty men from the original pontoon assembly detachment and 50 men from a casual draft were used as a nucleus for Pontoon Assembly Detachment Number 2. This unit arrived in the Russells on December 16. Its personnel erected a plant and a camp, and the first pontoon came off the line on January 31, 1944, approximately 6 weeks after the unit arrived on the island.

During the war this record was not equaled by any other unit. It was achieved by what was then approximately one half a complement. (Units Nos. 3, 4, and 5 later came out, each with a crew of 500 men.) This record resulted from proper planning, excellent relations with the island command, and showed the results of experience gained in the erection of the first plant which was built at Noumea.

Pontoon Assembly Detachment Number 2 manufactured approximately 16,000 pontoons in the first year, despite the fact that time consumed in plant and camp erection, time lost awaiting men to bring the unit to complement, and lack of knockdown pontoons in sufficient number to maintain production kept the plant out of operation and production for three months during this period. A large number of structures were also assembled and loaded for the Amphibious Forces during the first year.

SELECTION OF SITE FOR PLANT

In selecting a location for a pontoon-manufacturing plant, we kept in mind the fact that these plants must produce up to 25,000 pontoons before being dismantled in order to make their erection justifiable. It was, in general, not feasible to erect plants for only a few months of operation. There was a tendency to discontinue manufacturing when a plant was a thousand miles or so from the battle front.

When a general location, based upon ultimate market for pontoons, shipping facilities available, and availability of raw materials and plant supplies, had been selected, the actual plant site was chosen. A location near a naval supply depot, advance base construction depot, spare-parts depot, and equipment-overhaul depot was highly desirable.

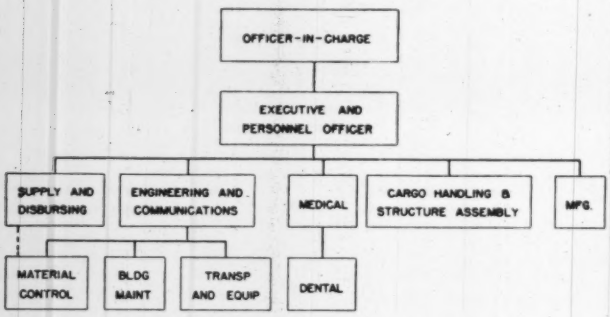
In selecting the actual site for the plant, a representative familiar with pontoon-manufacturing methods was sent to the spot to acquaint authorities with the functions of a pontoon assembly detachment. Photographs showing plant operation, and aerial views and complete layouts of existing plants were of considerable aid in explaining the requirements to these people.

The site to be selected for the factory and storage yard needed to be reasonably level and at a minimum of 5 ft above high tide, for the most part, comprising an area of about 1,500,000 sq ft. At least 1000 ft of bulkheaded waterfront was necessary to per-

mit LST's and barges to unload at low tide. The site selected was graded and surfaced before the assembly unit arrived in order to facilitate rapid plant erection. The units were not equipped to handle construction involving the movement of large quantities of earth. The site selected had to be close to the point where ships were unloaded so that materials could be supplied to them by barge. A pontoon assembly detachment received approximately 3000 tons of plate and pontoon gear each month and shipped a like amount. If it were desired that the unit side-load LST's with causeways and barges, it had to be located on a calm body of water where these structures could be assembled and where six to eight LST's could be anchored for loading.

PERSONNEL OF A PONTOON ASSEMBLY DETACHMENT

Pontoon assembly detachments were eventually provided with a complement of 17 officers and 500 men. This comple-



ORGANIZATION DIAGRAM OF PONTOON ASSEMBLY DETACHMENT

ment was designed for the operation of the finished plant and depot. Each unit built its own plant and camp, using factory workers under the supervision of the few carpenters, electricians, and plumbers who subsequently were employed in plant and camp maintenance. New units being organized found it desirable to have at least one officer with pontoon-manufacturing experience available in an advisory capacity so that a well-balanced crew could be selected. It was found desirable to send out with the unit a minimum of 25 experienced factory workers who had worked at various points on the assembly line.

Officers with varied experience were selected so that the unit would have a well-balanced engineering organization. The list included eight civil-engineer-corps officers, one medical officer, one dental officer, and a supply-corps officer. An organization diagram is shown herewith.

The officer in charge established policy and, as a general rule, worked directly under the commander of the naval base.

The executive officer had complete charge of personnel and the distribution of personnel among the various divisions of the organization.

The engineering officer, a structural engineer, was responsible for handling communications, filing requisitions for pontoon gear, and for the preparation of designs for special pontoon structures and accessories. Under him was the material control officer whose job it was to initiate orders for pontoon gear and factory supplies. Also under the engineering officer were the plant and camp maintenance officer, and the equipment and transportation maintenance and operation officer.

The medical department was in charge of a doctor familiar with eye treatment. Under the medical officer was a dental officer. Sick calls and dental work were so handled as to treat routine cases when the men were off shift.

Production was under a factory superintendent who was a civil-engineer-corps officer experienced in pontoon manufacturing.

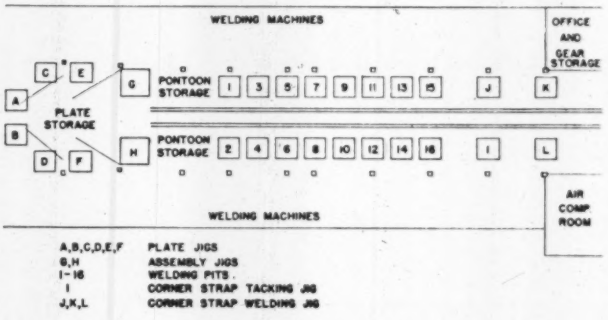
Cargo-handling operations and structure-assembly work were in charge of the waterfront officer. At times those organizing new units or supplying new officers to existing units tried to flood pontoon assembly detachments with officers experienced in the assembly of structures. This was not desirable as one officer in a unit handled all of this type of work.

The supply officer prepared all requisitions for materials and equipment for the plant upon recommendation of the material-control officer in the Engineering Department. The inventory of all pontoon gear and knockdown material and the subsequent report on it were handled by the material-control officer. The supply officer handled the issue of all expendable supplies. This officer was also responsible for disbursing, ship's service and ship's store activities, and enlisted-men's mess.

Each officer was responsible for the work of his department on a 24-hour basis, relying a great deal upon his chief petty officers or first-class men to handle the details of operating each shift.

PLANT OPERATION

The T-6 plant, a layout of which is given, was operated on a three-shift basis. Shift No. 1 started at 0600 (6 a.m.), and secured at 1200; No. 2 started at 1200, and secured at 1800; No. 3



LAYOUT OF T-6 PLANT

started at 2100, after the movie, and had ½ hour off for chow at 2400, and secured at 0330. Welding machines were serviced each day when machines were down. Machines failing during the shift were removed and replaced. It was found advisable to have spare machines along the line, available for quick switching, as considerable repair was necessary inasmuch as many of the machines had over 6000 hours of use. The factory was operated on a 6-hour shift, three shifts per day, seven-day-per-week basis.

On a 6-hour shift, the production record given in Table 1 was obtained.

TABLE 1 PONTOON PRODUCTION

Six plate jigs	24 plates each
Two assembly jigs	12 pontoons each
Sixteen pits	24 pontoons with 24 welders
One corner-strap jig	24 pontoons
Three corner-strap welding (A frames)	8 pontoons each

The pontoons flowed through the plant in the following manner: Plates and ribs were stored in the yard adjacent to end of the plant where the plate jigs A, B, C, D, E, and F were located (see plant layout). This material was brought into the plant daily by means of finger lifts. The plates were loaded on jigs by jib cranes.

After the ribs were welded onto the plates, the finished plates were stored adjacent to the assembly jigs. Pontoons were tacked together in the assembly jigs and trunnions were installed. Plates were handled in this operation by jib cranes. Pontoons coming out of the assembly jigs were loaded on a low railroad car and all exposed plate edges were gone over with a wire buffing wheel in order to remove rust and scale. From there they went to the temporary storage pile located between the assembly jigs and the pits. Inasmuch as an assembled pontoon had to be available to be put into each pit at the end of each shift or the beginning of the next one, it was necessary to have at least sixteen pontoons in this surge pile at this time.

In the pits the pontoon was suspended by trunnions and could be indexed around and held in one of eight positions in order that all seams could be brought into a horizontal position for welding. Inside welding was done first, then the outside seams, and last the manhole. The pipe plugs were then inserted and a 15-lb air pressure applied. Leaks were detected by painting with a soap solution the seams and also portions of side and end plates where ribs had been welded. Each pit welder repaired his own leaks.

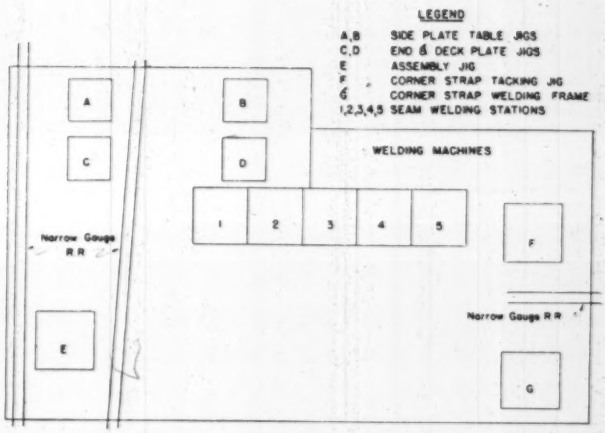
After it was established that all leaks had been stopped, the pontoon was removed from the pit and placed on a low railway car. The pontoon was moved down to the corner-strap tacking jig and upon completion of this operation it was held in an A-frame to complete welding of the corner straps. The pontoon was then placed on a railway car of special design which permitted it to move through the water test and paint shop and then to the storage pit or the assembly ways, where it was removed from the car. The cars were returned on an outside track and re-entered the plant at a point near the corner-strap station. Railway cars were moved by a low-platform industrial truck, powered by an internal-combustion engine.

As pointed out, one pontoon could be produced for each three men in the plant. This included supervision, testing, painting, and plant cleanup. A pit welder working alone in a pit produced and air-tested one pontoon per shift. If two welders worked in one pit, two pontoons had to be completed. New welders worked overtime to accomplish this but most experienced welders completed their job in less than 5 hours and were through for the day. These men frequently worked in temperatures inside the pontoon as high as 130 F. An average of 70 men per shift were required to maintain this production.

The T-7 plant, a layout of which is shown, operated from 0600 to 1200. This shop had a capacity of six pontoons per shift and had four table jigs, one assembly jig, five seam-welding stations, one corner-strap jig, and one corner-strap welding A-frame. Seventeen to eighteen men in this plant were required to maintain this production. The demand for T-7 pontoons varied with the type of structures being shipped but a ratio of 10 to 1 between T-6 and T-7 production was found to be satisfactory.

In general, the flow of material through the T-7 plant was similar to that of the T-6 plant. This plant was built in a modified 40 × 100-ft arch-rib building. Material was handled by overhead electric hoists for the plate jigs, a jib crane for the assembly jig, a finger lift handled pontoons in and out of the seam-welding stations, and overhead electric hoists were used again in the corner-strap welding and corner-strap tacking stations. Upon completion of all operations the pontoon was placed on a special railway car and moved through the same water test and paint shop as used for the T-6 design.

Each shift was supervised by one chief petty officer. The general supervision of both plants was under a civil-engineer-corps officer, the factory superintendent.



LAYOUT OF T-7 BUILDING

Cargo-handling and barge-assembly work were conducted on a 24-hour basis when the volume of work made this necessary. When neither cargo-handling nor assembly work was available men were used both to repack and to salvage pontoon gear.

Food was served in the galley between 0530 and 0730, 1115 and 1230, 1715 and 1830, and 2400 to 0030. Two shifts of cooks were used, one working the breakfast and noon meal and the others the evening and midnight lunch.

Office, warehouse crews, and camp and plant maintenance were operated on a 6-day week, but with men on duty in off hours. These crews worked a 0730 to 1130, and 1300 to 1700 shift.

The approximate number of men required by Pontoon Assembly Detachment Number 2, in its various departments, to give the peak production reached, of 2300 pontoons per month, is given in Table 2.

TABLE 2 COMPLEMENT OF PONTOON ASSEMBLY DETACHMENT NUMBER 2

T-6 plant	220
T-7 plant	18
Waterfront	60
Office, galley, and guards	40
Other shops and warehouses	42
Total	380

The quantities of material used in an average month to manufacture 2000 pontoons are given in Table 3.

TABLE 3 EXPENDABLE SUPPLIES TO BUILD 2000 PONTOONS PER MONTH

Welders' gloves	100 pairs
Carbide	180 lb
Oxygen	7 cylinders
Clean helmet glass	3200 pieces
Dark helmet glass	100 pieces
Wire buffing wheels	80
Welding rod	70000 lb
Paint primer	1000 gal
Paint finish	1000 gal
Electrode holders	40
Gasoline	60000 gal
Steel plate and shapes	2096 tons

Tables 4 and 5 show the equipment and tools used in the T-6 and T-7 plants, respectively.

TABLE 4 EQUIPMENT AND TOOLS USED IN T-6 FACTORY

48	Welding machines
2	Finger lifts
1	Tow motor (Readypower)
1	Cherry picker
2	Portable acetylene burning outfits
1	Brazing outfit
2	Grinding tables
2	Flat-top jigs (end plates)
2	Flat-top jigs (side plates)
2	Flat-top jigs (deck and bottom)
4	Jib cranes
4	1-Ton hoists (flat tops and assembly jigs)
8	1 1/2-Ton hoists (pits)
2	2-ton hoists (A-frames and corner-strap jig)
2	Assembly jigs
4	Fire extinguishers
4	Plate cables and hooks; flat tops
2	Assembly-jig chains and hooks (4 clamp)
8	Lift hooks for flat-tops and assembly jigs
8	Pinch bars for assembly jigs
20	Small wedges for assembly jigs
8	Large wedges for assembly jigs
30	Clamps for backup strips
8	T-bar gages for side plates
2	"Come alongs" for assembly jigs
2	Air power buffers (portable)
45	Trunnion plates (with clips)
45	Trunnion plates (plain)
500	5/8 In. × 1 1/2-in. bolts for trunnion plates
8	Chains for lifting pontoons from pits
1	Corner-strap jig
3	A-frames
18	Small flatcars for inside factory
30	Large flatcars for outside factory
16	Pit stanchions (plain)
16	Pit stanchions (with locks)
17	Plug wrenches (for pits and hydro)
100	Ball-peen hammers (2 lb)
100	Wire brushes (hand for pits)
12	Wire brushes for air buffer (6 in. round)
12	Small wedges for corner-strap jig
8	Large wedges for corner-strap jig
12	8-lb sledge hammers
2	Large crowbars
6	5/8 In. open-end spud bars
6	Checking plugs for A-frames
3	Checking bars or straps frames
16	Airtest plugs with quick make-or-break connections
16	G-bar gages (for pits)
8	Airtest connections with quick make-and-break for hydro
8	Water connections to pontoons for hydro
3	Paint pots (complete with heads and connections)
6	Sets of extra air- and fuel-line connections
2	Air stabilizers or reducers type H.L.C.
100	Feet of air hose and connections
100	Feet of fuel hose and connections
6	Spray guns
24	Spray masks
2	Wheelbarrows
170	Welding helmets (complete)
1000	Clear glass for helmets
300	Pairs welders gloves
100	Pairs canvas gloves (short cuff)
10	Pairs safety goggles
12	Pairs burning goggles
12	Lighters for burning units
2	Air chipping hammers
1	Large shop vise
1	18-In. pipe wrench for hydro
4	2-In. plug taps
4	Trash wagons for outside
2	Welding-rod cabinets
12	Brooms
2	Boxes chalk
6	Carborundum grinding wheels
3	Flashlights for pit inspectors (complete)
3	Adjustable (crescent) wrenches 6 in., 9 in., 15 in
2	Screw drivers 6 in., 12 in.
6	Foot tape measure
1	Combination square and protractor, 12 in.
2	Pliers
1	Set socket wrenches
1	Set open-end wrenches
1	Hacksaw
1	Carpenter saw
2	Dividers, 1, 6 in., 1, 12 in.
2	Calipers, 1 inside, 1 outside, 6 in.
1	24-In. carpenter square
1	Center punch
1	Carpenter hammer
1	Mechanic hammer
3	Mechanic pipe wrenches, 10 in., 18 in., 24 in.
9	1/16-In. open-end wrenches
	Assorted smooth and coarse files, also three-cornered
1	Rasp
1	Hatchet
1	Brace and assorted drills
6	Padlocks
	C-clamps 6 in., 9 in., 12 in., and 18 in.
6	Oil cans
2	Grease guns
	Extra springs for welders helmets
	Soapstone
2	7 In. clamps for use on A-frames
24	Small brushes for testing pontoons

SIDE LOADING OF CAUSEWAYS AND BARGES ON LST'S

Experience with the handling of pontoons showed that it would be a great advantage if causeways and barges could be made available in assembled form for assault operations. The side-carrying of causeways on LST's proved to be practical in the landings on Sicily. This practice provided structures which were available for use on "D" Day and by carrying them on the sides of the ships, released valuable cargo space in transports for other purposes.

Brackets were welded approximately 10 ft below and parallel to the deck of the LST. Hinge bars were welded to the deck angles of causeways and barges. The method of loading used at Pontoon Assembly Detachment Number 2 was to list the LST and to float the barge or causeway in until the hinge bars rested on the brackets. A 75-ton-capacity floating crane was then used to hinge the barge or causeway up against the side of the ship. The structure was quickly secured by means of vehicle chains between the top barge angle and the decks of the ship, thus releasing the crane. The turnbuckles and additional lashing chains and braces were then installed to secure the structures to withstand wave action at sea.

TABLE 5 EQUIPMENT AND TOOLS REQUIRED FOR NEW SETUP OF T-7 FACTORY

14	Welding machines (minimum for six pontoon production)
5	Pit frames and platforms
2	Flat-top jigs, side plates
1	Flat-top jigs, back plates
1	Flat-top jigs, deck plates
1	Assembly jig
1	Corner-strap jig
1	A-frame (corner strap)
2	Acetylene burning outfits
2	1-Ton hoists (Flat-top jigs and I-beam assembly)
2	2-Ton hoists (Flat-top jig and corner-strap jig)
8	Cars for complete pontoons (minimum)
4	Flatcars and track from tables to assembly jig
1	Finger lift
12	Trunnion plates (for deck plates)
12	Trunnion plates (for curved bottoms)
4	8-Lb sledge hammers
12	Ball-peen hammers
12	Chipping hammers and wire brushes
6	Pinch or wrecking bars
	Large and small wedges for all jigs
2	Buffing motors and wire wheels
2	3-Ton hydraulic jacks (12 in. height compressed)

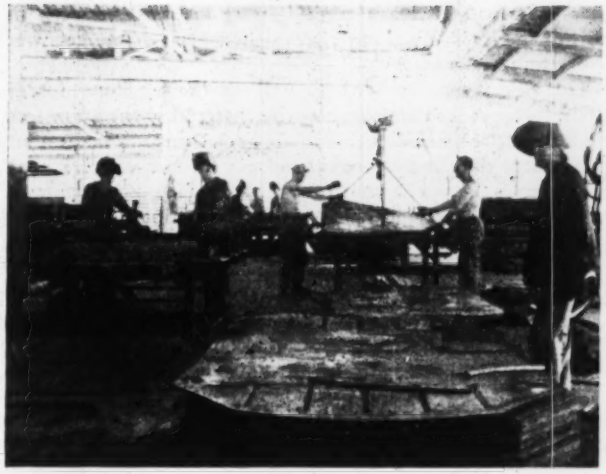
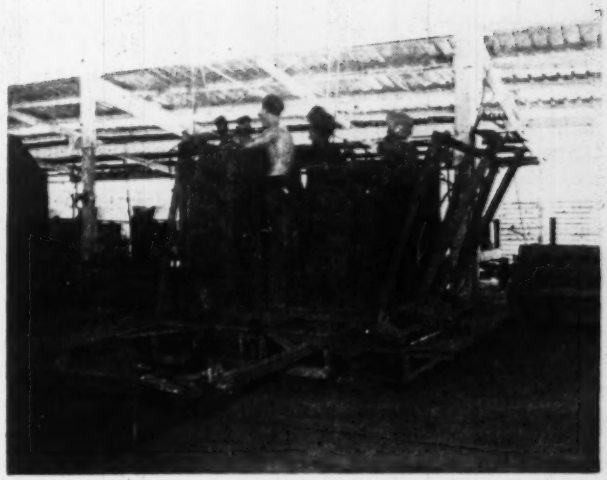
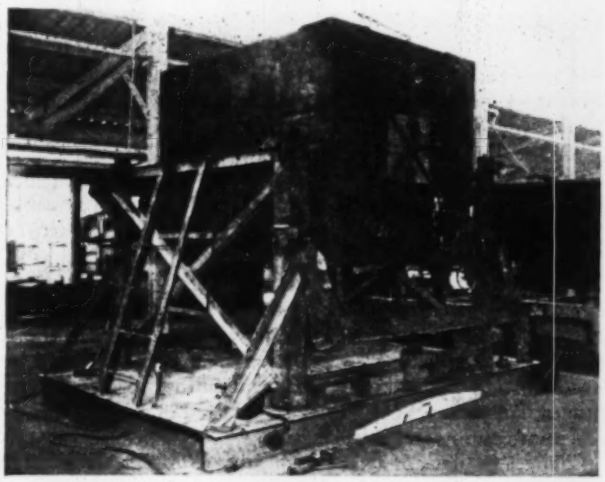


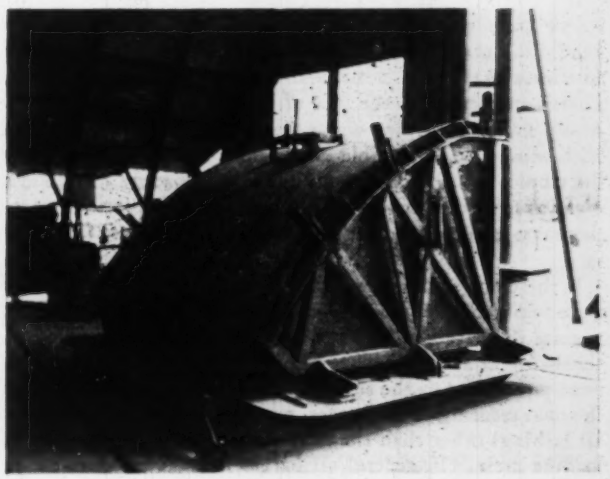
PLATE JIGS T-6 PLANT



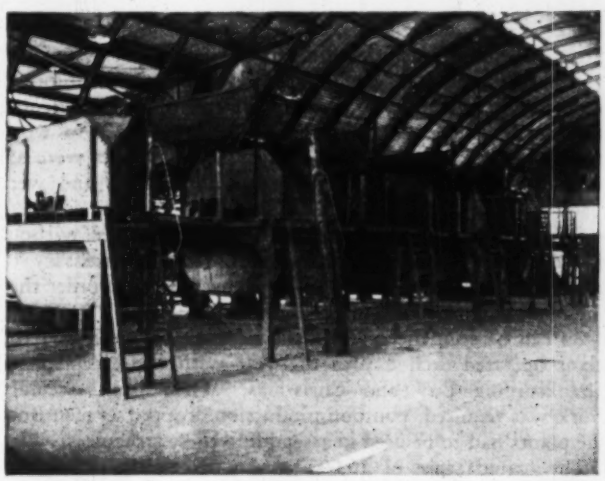
ASSEMBLY JIG T-6 PLANT



T-6 CORNER-STRAP TACKING JIG



ASSEMBLY JIG T-7 PLANT



SEAM-WELDING STATIONS T-7 PLANT

SHEARING BACK-UP STRIPS FROM PONTOON PLATE

Approximately 40 men were required to load five ships with barges or seven ships with causeways, in a 12-hour day. Ten men operated the 5-ton floating crane, 10 men manned the 75-ton floating crane, and 20 men supplied barges and causeways to the ships and laid out the lashing chains.

At times it took as much as two hours for an LST to list from starboard to port or vice versa. Operating with only one 75-ton crane made it imperative that this crane did not stand idle during the loading operations. For this reason it was necessary to have three to four ships available at daybreak with which to work. These ships were anchored across the channel, parallel to each other and 400 to 500 ft apart. At least one of the ships had the required list and barges and causeways in place at daybreak. Other ships were in the process of listing. Each barge or causeway required about 20 min time to lift into place, and about 5 min were required to secure the barge with three vehicle chains. Approximately 20 min were required to move the 75-ton crane alongside of another ship. In the meantime, the ship which had been loaded on the portside was listed to starboard and when the ship was ready and the crane was released from another ship, the loading of the first ship was completed.

One crew was used throughout the loading operation to handle the cranes, to secure the barge temporarily in order to release the 75-ton crane, and to lay out the vehicle chains. This is important as the loss of 10 min or so on each barge would make the loading of five ships with barges or seven ships with causeways impossible in a 12-hour day. Twelve hours in the tropics is the period of daylight. No loading was done at night as more danger was involved and in this particular case, there was never a sufficient backlog of ships to make this necessary.

In these operations crews from a pontoon assembly battalion were available to handle the barges en route to the target and to operate the barges and causeways upon arrival. These crews, consisting of about 20 men, a chief, and sometimes an officer, were put aboard as the ship was being loaded. They handled the final securing of the barges, putting on the turnbuckles and all lashings other than the temporary lashings installed by the loading crew. In general all barges and causeways were assembled and fitted with hinge bars by Pontoon Assembly Detachment Number 2.

All extra fittings such as anchor hoists, ramps, etc., were installed by the crews supplied by pontoon assembly battalions. Actual loading was done by Pontoon Assembly Detachment Number 2.

Loading gear was supplied with each barge and causeway set. This gear was designed to permit causeways or barges to be loaded by means of power supplied by the ship's anchor winch. This gear was placed aboard each ship. It was never found necessary to use this gear in the loading of ships by Pontoon Assembly Detachment Number 2, as the 75-ton floating crane provided a more rapid and efficient method of loading, but the gear was available in case it was necessary to reload the ship at some other location.

WORKING CONDITIONS

The temperatures throughout the year ranged between 85 and 95 F in the shade. Humidity was very high and the average rainfall was approximately 160 in. per year. January, February, March, and April were considered to be the wet season and during these months the rainfall sometimes was 20 inches or over.

The most difficult working conditions were those encountered by the welders working inside of the pontoons. Here a temperature of approximately 130 F was found to prevail.

Considerable eye trouble, both flashes and foreign bodies, was experienced. Flash curtains were installed between the pits. The trouble was more prevalent when two welders were working in each pit.

Goggles were provided for all workers. Some foreign bodies were picked up from abrasive material in the air or from floor dust, due to careless use of air in cleaning. The heat and consequent sweating created a tendency for men to work without goggles, but strict control was maintained, and men found operating grinders and buffing wheels or chipping scale from welds while not wearing goggles were put on report. Eye trouble was much more prevalent when new men were being trained in the plant.

Due to the heat, fungus infections were prevalent. Some men reacted to the leather welding gloves and their hands broke out badly. Light cotton gloves were tried under the welding gloves and seemed to help in cases where men had this trouble.

Men suffering from industrial fatigue were removed from the plant and were given jobs in the open such as work on the waterfront or truck driving.

Cat fever was prevalent at times but the introduction of warm showers seemed to reduce this trouble.

OPERATING PROBLEMS

In the operation of a plant of this kind at an advance base, the supply problem was always a major one. One remarkable fact was that during the 2 years of operation no shipment of supplies for the plant was lost through enemy action.

Lack of shipping space sometimes held up steel shipments, but a 2-months' minimum supply was maintained if possible. A 6-months' supply of plant supplies, such as welding gloves, electrode holders, and grinding wheels, was maintained at all times. Gasoline, oil, camp gear, and other items used generally in the service were drawn from local sources as needed.

Considerable training of personnel was required. In the 2-year period, approximately 450 men were given welding instruction. In addition to this, equipment operators were trained, and at times classes were conducted in subjects such as blueprint reading and mathematics.

Changes in plans of attack frequently required delivering of structures on short notice. The 75-ton floating crane, for example, was erected and tested in 7 days in order that barges could be loaded for the Guam operation. An LST damaged in maneuvers made it necessary to outfit another ship with brackets and anchor loops and to transfer the cargo to this ship in 12 hr in order that the convoy would not be held up on the Okinawa deal. In another move last-minute information showed that 2 × 30 causeways were required. The dispatch was received at midnight, a crew was set to work building the ways, and in 12 days 1800 pontoons were assembled into causeways, fitted with hinge bars, and were ready to load.

At one time a shipment of pontoon steel arrived without the necessary corner back-up angles. It was necessary to build a power shear from HD-7 bulldozer parts in order that the plant could be kept in production.

As can be seen there was always plenty of work, and the plant operated each day in the year with the exception of Thanksgiving Day and Christmas. When barge assembly work was required, pontoon production dropped as men from the plants had to be used in assembling these structures.

The manufacture of 16,000 pontoons, twelve shiploads, and the building of approximately 50 per cent of the barges and causeways for the invasion of Guam, Pelelieu, the Philippines, and Okinawa, all done in 1 year, proved beyond any doubt that the building of these plants at various locations in the Pacific was very necessary.

COMPRESSION DISTILLATION

By ALLEN LATHAM, JR.

ARTHUR D. LITTLE, INC., CAMBRIDGE, MASS.

THE possibility of attaining unusually high fuel economy in distillation by using the compression method has been recognized for many years, but not until the recent war was this method widely used. Fundamentally the high fuel economy of this process depends on compression of the vapor leaving the evaporation compartment so that it can be used in the steam chest in place of process steam. The most recently developed units for distillation of sea water are capable of producing 175 lb of distilled water for each pound of fuel consumed. This represents what is believed to be the highest fuel economy of any practical system of evaporation, with the exception of solar evaporators and systems which are tied into other plant operations, as in the case of a "reducing-valve evaporator."

HISTORY AND DEVELOPMENT OF SYSTEM

Practical application of this principle using jet compressors was attempted as early as 1856.[1] In 1881, Jules Weibel of Geneva, Switzerland, obtained a patent,[2] which discloses the use of a reciprocating compressor for this purpose. The earliest American inventor in this field appears to have been Addison G. Waterhouse of Highland Park, Conn., who secured a patent[3] in 1897. Development of this art was very slow until after the first world war, when a few custom-built commercial installations were successfully made by two or three European firms. No American industrial applications of mechanical compression distillation are noted in the literature or known to the author.

Shortly before the late war intensive development of compression distillation, as applied to the production of distilled water from sea water, was undertaken at the laboratories of the author's company under the vigorous leadership of Dr. R. V. Kleinschmidt (now Commodore Kleinschmidt, U.S.N.R.), who was first to advocate mechanical compression distillation for naval and other military uses. His first experimental unit operated so well that officials of the Armed Services were called in for a demonstration. Sensing the strategic significance of the Kleinschmidt unit, these officials actively promoted its development for a specific application. This and subsequent models were manufactured by E. B. Badger & Sons Company of Boston under co-operative arrangement with Arthur D. Little, Inc.

The performance of the Kleinschmidt units in their early applications was so encouraging that even before the attack on Pearl Harbor three specialized units were under development for the Armed Forces. There is now enough Kleinschmidt compression-distillation equipment in service to produce pure distilled water for the daily needs of over a million men. This wide acceptance grew from outstanding performance, particularly with respect to economy of fuel and ease of operation. Devices and methods used in this advance of the art are covered by a number of United States and foreign patents and patent applications assigned to the author's company.

[1] "Evaporation," by A. L. Webre and C. S. Robinson, Chemical Catalog Company, New York, N. Y., 1926, p. 93.

[2] U. S. Patent No. 236,657, Jules Weibel, 1881.

[3] U. S. Patent No. 585,943, A. G. Waterhouse, 1897.

Contributed by the Power Division and presented at the Annual Meeting, New York, N. Y., November 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

It appears likely that there is a much broader field of practical application for compression distillation than in the production of distilled water. In order that more engineers may have a well-founded understanding of this process, the remainder of this paper will be devoted to an introduction to the significant engineering characteristics of compression distillation.

CYCLE OF OPERATIONS

Fig. 1 is a diagrammatic representation of this process as applied to the production of fresh water from sea water.

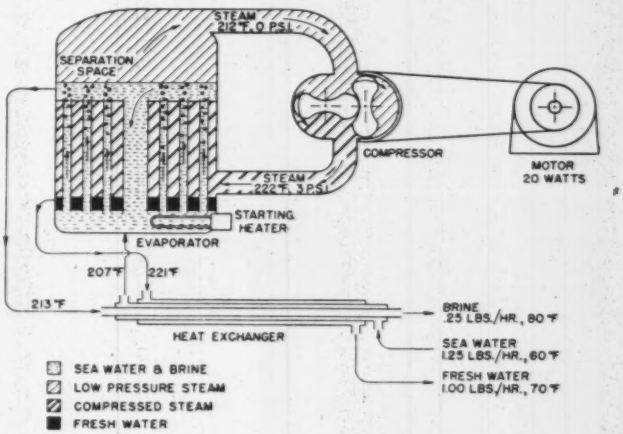


FIG. 1 DIAGRAMMATIC REPRESENTATION OF COMPRESSION DISTILLATION AS APPLIED TO DISTILLATION OF SEA WATER

Normal operation is preceded by a period of heating to bring the apparatus and its contents to operating temperature. As soon as the evaporator has been filled with steam, the still may be turned on stream for continuous operation. The sea-water feed enters by way of a triple passage liquid-to-liquid heat exchanger which extracts heat from the outgoing distillate and brine to heat the feed. The feed at about 207 F is then introduced to the evaporator where it mixes in a relatively large volume of brine which circulates by natural circulation through the vertical tubes. Steam at, or slightly above, atmospheric pressure is led from the evaporation space through an entrainment separator to the compressor which raises the pressure to about 3 psig, thus raising its saturation temperature to about 222 F. Since the brine in the evaporation space boils at about 213 F, there is a temperature differential of about 9 F between the compressed steam and the boiling brine to permit transfer of heat from the former to the latter. Substantially all of the latent heat of the compressed steam is used in maintaining evaporation in the evaporation space; thus no separate condenser or cooling water is required.

With a unit of 1000 gal per day capacity, the production of 1 lb per hr of distillate requires an electric-power expenditure of about 20 w. To produce distillate at the same rate in a single-effect evaporator would require approximately 300 w. From this it is apparent that the Kleinschmidt compression-

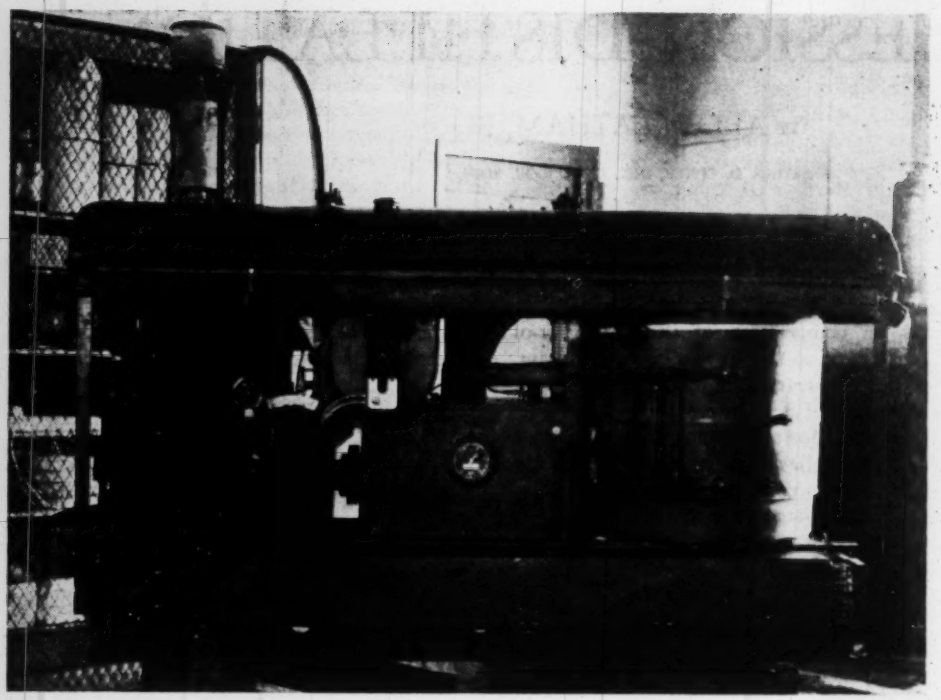


FIG. 2 FIRST GASOLINE-ENGINE-DRIVEN COMPRESSION-DISTILLATION UNIT

distillation process as applied to sea-water distillation has an economy equivalent to some 15 or more effects. Furthermore, a compression-distillation unit is far more simple to operate than a multiple-effect unit. The connections, heat-transfer apparatus, and controls are as simple as those on a single-effect evaporator. Ordinarily, control of the operation is made entirely through adjustment of the flow of feed only. That this process requires very little operational attention is evidenced by the fact that on shop tests units set up for manual control have been left running day and night for as long as a week without adjustment of any sort.

Fig. 2 is a view taken in November, 1941, of the first internal-combustion engine-driven compression-distillation unit ever built. This unit was developed in the laboratories of the author's company, under contract with the Marine Corps. Fig. 3 shows a recent production unit which is an outgrowth of the original unit shown in Fig. 2. Subsequent laboratory development work has resulted in an improved unit shown in Fig. 4. This unit has a fuel economy about threefold better than the original unit and at the same time represents marked advances in simplicity, ease of operation, and general serviceability.

BASIC PRINCIPLES OF PROCESS

A more complete understanding of the basic principles of this process may be obtained through a study of the relationship between the heat quantities and temperatures throughout the process. Fig. 5 is a graphical representation of this relationship. Construction of this diagram is based upon the usual consideration of heat balance. Cold feed entering at 60 F is heated (inclined dot-dash line) to 207 F by heat exchange with the outgoing condensate and overflow (inclined solid line). Following final heating in the evaporator from 207 F to 213 F, the hot feed is vaporized (horizontal dot-dash line) by heat ex-

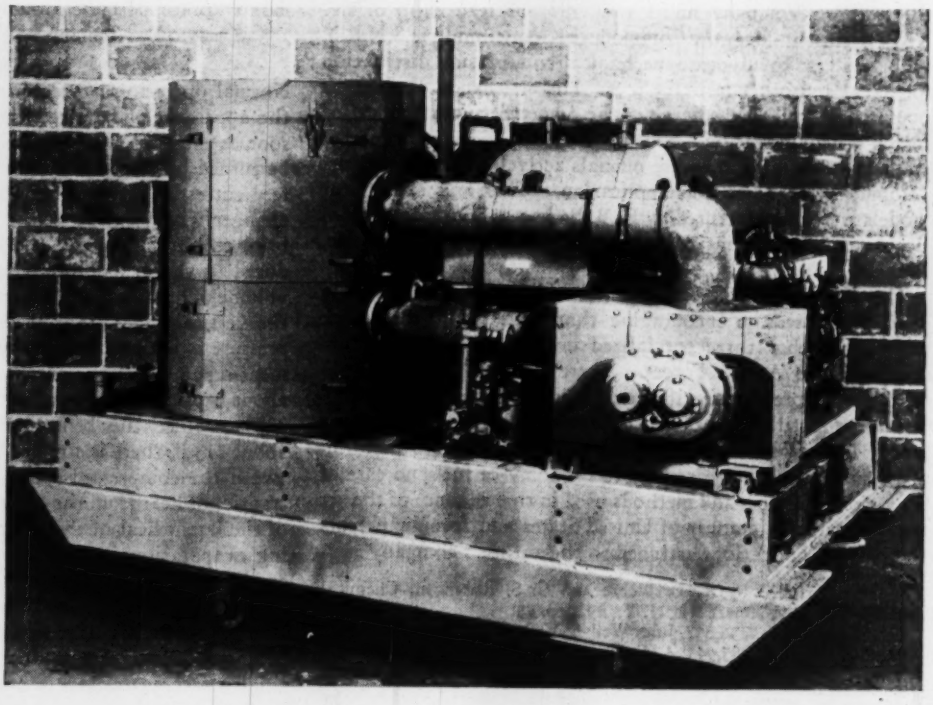


FIG. 3 PRODUCTION MODEL

change with the condensing compressed steam (horizontal solid line). It is clearly evident that at all points in the process a suitable temperature differential exists to permit the exchange of heat from the condensate and overflow for preheating the feed and from the condensing compressed steam for evaporating the feed. The temperature differentials indicated are 10 F in the heat exchanger and 9 F in the condenser-evaporator. The diagram shows an excess of heat on the high-temperature side (right-hand end of horizontal solid line) which allows for heat loss from the process to the surroundings through the insulation and for an operating margin.

For instance, the operation of the process may be stabilized by allowing a portion of this excess heat to pass from the process, by venting a small amount of steam to the atmosphere. For this purpose the low-pressure steam-separating space is often connected to the atmosphere through a breather vent. As indicated by the diagram, which is based on a capacity of 1000 gal per day, the total excess heat allowed for insulation losses and stabilization losses may be of the order of 55 Btu per lb of distillate. It may be noted also that by adding 68 Btu to the process at the compressor, not only is this excess supplied, but also a temperature differential of 9 F is created for operation of the condenser-evaporator. In this manner heat is recirculated to the extent of 960 Btu in the condenser-evaporator and 190 Btu in the heat exchanger. Thus the 68 Btu added at the compressor serves to circulate a total of 1160 Btu per lb of distillate, as well as to supply a surplus of heat for operational leeway.

It is of interest to note that for this cycle where all-electric drive is used, the efficiency of the steam compressor need not be high. The amount of energy required for this compression ideally would be only about 15 Btu compared with the 68 Btu which on moderate-sized units has been found practical. Actually, the full 68 Btu is not ordinarily added entirely at the compressor. Perhaps 35 Btu is put in at this point and the rest is added by use of electric heaters in the evaporation zone.

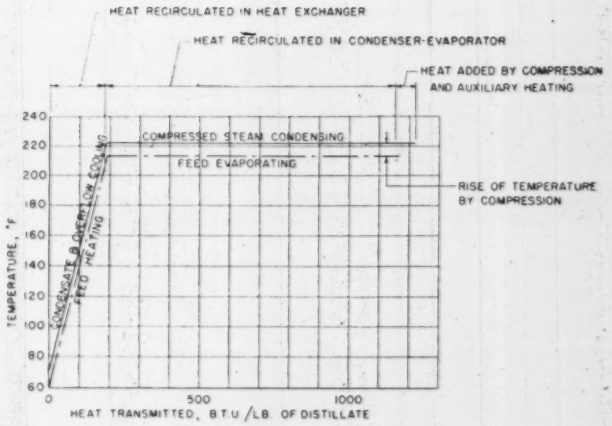


FIG. 5 TEMPERATURE-HEAT QUANTITY RELATIONSHIP IN COMPRESSION-DISTILLATION UNIT

EFFECT OF SCALE FORMATION

As in many evaporation processes, the compression-distillation process is usually affected by scale formation on the evaporation surface. In some ways the effect of scale formation on the performance of a compression evaporator is more noticeable than on more conventional types. The added resistance to heat transfer produced by scale requires an increase in compressed steam pressure in order to maintain constant output. This results in more energy entering the system by way of the compressor. In an all-electric drive the added energy input from the compressor may be compensated for by a decreased use of the electric heater, thereby maintaining a practically constant total electrical input regardless of scale formation. A rather different situation exists in the case of an internal-combustion-engine drive equipped for waste-heat recovery. In this case, the waste heat is more than sufficient to perform the same function as the electric heaters in an electric drive. Scale formation leads to a heavier load on the engine, which in turn gives up more waste heat, which of course is not needed for operational leeway. Thus the engine-driven unit has a characteristic of low fuel consumption when the evaporator is clean and gradually increasing fuel consumption as scale formation progresses. In spite of this, however, the over-all economy of the engine drive is difficult to surpass with any other drive.

Fig. 6 shows the field-test results of an experimental unit of this type. The evaporator was started clean and operated for a total of 730 hr before being shut down for cleaning. During this time the compressed steam pressure rose from 3.1

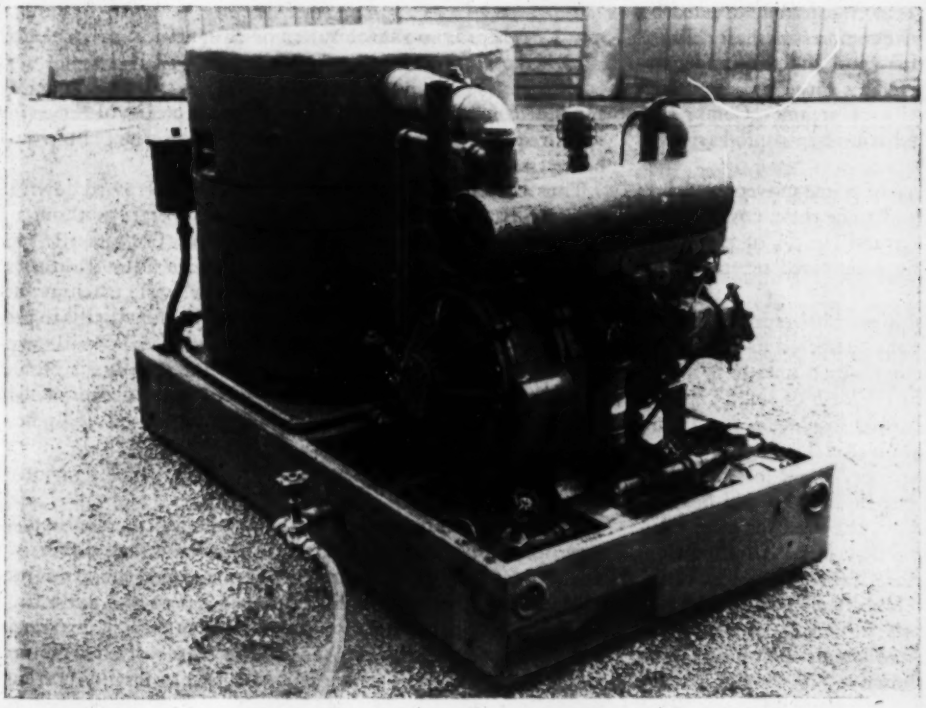


FIG. 4 RECENT DEVELOPMENT MODEL

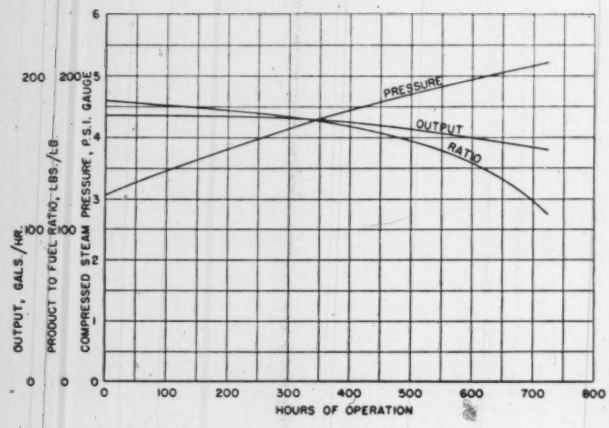


FIG. 6 PERFORMANCE OF GASOLINE-ENGINE-DRIVEN COMPRESSION-DISTILLATION UNIT

psig to 5.3 psig, an increase of 71 per cent. Corresponding drop in product-to-fuel ratio was 185 to 122, or 34 per cent. For this same period the capacity dropped from 169 to 152 gal per hr, or only 10 per cent.

LIMITATIONS IN ATTAINING HIGH FUEL ECONOMY

Under the foregoing discussion of the effect of scale formation, the fact that the fuel economy is somewhat governed by the compressed vapor pressure is noted. In theory, it may be held that any increase in pressure differential imposed upon the compressor will tend to reduce the fuel economy. Since it is this pressure differential which produces the temperature differential in the condenser-evaporator, it is evident that temperature differential is a factor of primary design significance. The ability of a condenser-evaporator-compressor combination to produce distillate at a low expenditure of fuel by the prime mover operating the compressor may be expressed in terms of the amount of energy recirculated as heat transferred, divided by the amount of energy delivered to the compressor shaft. Fig. 7 shows the relationship between this ratio and the condenser-evaporator temperature differential. This curve was calculated from the thermodynamic properties of steam. Compressor efficiency of 75 per cent on the adiabatic insentropic basis was assumed.

In practice, a considerable variety of prime movers or drives for the compressor may be used, and since these cover a wide range of thermal efficiencies, the over-all ratio of pounds of distillate to pounds of fuel must be determined separately for each case.

Although the foregoing relationship establishes definite fundamental limits to the application of the compression-distillation process, there are a number of factors which impose narrower limits in practice. Particularly in the case of small-capacity units, the loss of heat through thermal insulation to the surroundings presents a considerable problem. Leakage of a small amount of steam may be equally serious. Heat loss by reason of the temperature differential in the liquid-to-liquid heat exchanger is similarly important. Also, the need for a considerable excess of heat to insure operability under all conditions prevents the attainment of the theoretical limit. Most of the compression-distillation units developed thus far have been in capacities less than 250 gal per hr. In units of this size, the practical limitations just indicated result in operation at points far to the left of the curve shown in Fig. 7—about at the intersection of the 10-deg differential line with the 15 ratio line. For any particular application, the optimum design may be determined only after careful consideration of a great variety of factors, such as the relationship represented in Fig. 7, the cost of heat-transfer surface, the cost of insulation, the cost of power, and the limitations of available steam compressors.

COMPRESSION EQUIPMENT

Progress in development of compression distillation has always been hindered by lack of suitable compression equipment. Development of compression equipment for this purpose is still by no means complete. Ordinarily, the high quality standards for the distillate rule out the use of any lubricant in the compression space. In fact, this requirement not only makes it impossible to use the most readily available types of compression equipment, but also requires that whatever equipment is used must be specially fitted with seals to prevent the passage of lubricating oil from the working parts into the compression space. Furthermore, the gradual rise in pressure caused by scale (see Fig. 6) conflicts with the basic characteristics of centrifugal and axial-flow compressors, so that if these

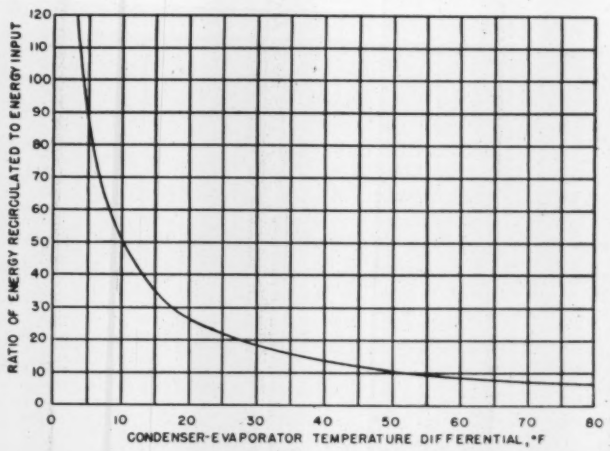


FIG. 7 CALCULATED PERFORMANCE OF COMPRESSION-DISTILLATION PROCESS

types of compressors are to be used, some means of removing scale frequently or of compensating for the pressure rise would be necessary.

Thus the choice for many applications is narrowed down to positive-displacement compressors which operate without oil in the compression space. Possibly the Connersville-type blower is the best known of the types which fall within these requirements. In fact a great many Connersville machines are being used in this service today. However, for distillate production of over 300 gal per hr per unit, the Connersville type of machine does not show promise of being readily adaptable. Current development of improved types of compressors may make a wider choice of satisfactory compression equipment possible in the near future.

FUTURE POSSIBILITIES

The extensive application of compression distillation in military operations has demonstrated it to be thoroughly practical and outstandingly economical of fuel. Indeed, the experience gained through these applications has led to the realization that the original goals, which initially appeared extremely difficult, were too modest. Today the status of the compression-distillation art is sufficiently advanced to justify its recognition as a radically new factor in the field of distillation and evaporation.

HIGH-STRENGTH PLASTICS *in Future* AIRCRAFT DESIGN

Consideration of Low-Pressure-Molded Plastic Structures

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THE aircraft industry has long been cognizant of certain existing limitations peculiar to the fabrication of reinforced thin-metal bodies. Influenced by critical weight factors governing the design of aircraft, aeronautical engineers have been striving for years to achieve the pure monocoque structure in the interest of obtaining better strength-weight ratio. However, in view of the disadvantages associated with stressed thin sheet panels which may be summed up in two words, "local instability," it has become necessary to compromise. Hence, most airframes comprise component sections of a semimonocoque character which have been stiffened by attached reinforcing members, such as stringers, ribs, spars, bulkheads, and frames.

As a necessary adjunct to this form of stiffened thin-metal structure, the shop developed techniques and shop practices in line with organization setup to process thousands of detail parts before they reach the final assembly line. Subsequently, each component part, regardless of size or shape, becomes a separate detail and must undergo at least five individual operations. The normal flow pattern consists of raw-stock issue, cutting or shearing, blanking, forming, inspection, and assembly. Altogether an airplane comprises thousands upon thousands of detail parts matched and assembled with countless numbers of rivets and bolts. Obviously, large staffs of productive as well as nonproductive personnel are essential to co-ordinate and handle the multitude of operations embodied in the design and manufacture of modern aircraft.

EVENTS AND DEVELOPMENTS LEADING TO MORE EFFICIENT METHODS OF DESIGN AND PRODUCTION

Aircraft officials are fully aware of the limitation outlined. Most thinking along this line is concerned mainly with light alloy metals, since the industry is a metal fabricator. A development of a nonmetallic character would likely receive small consideration unless the advantages were outstandingly greater than existing methods. Also, the adoption of any foreign process in the plant would probably be contingent upon its workability feature with the fixed equipment already established. In conjunction with these requirements, recent progress made with new developments offers some interesting aspects of more simplified production. One process, the molding of high-strength plastics by methods commonly called "low pressure," holds significant possibilities for the future production of aircraft.

This process is flexible and lends itself readily to the construction of complicated shapes, open or closed, which would be impossible or at least unfeasible economically to duplicate by other methods, such as metal fabrication. In addition, the fact that low-density core materials can be combined with the faces of high-strength reinforced plastics to form sandwich-type panels makes the low-pressure process extremely useful in the production of aerodynamically clean and lightweight structure so necessary for efficient operation of aircraft.

An outstanding example of the sandwich type of construction is the experimental plastic fuselage for the BT-15 airplane. Conceived and built in the aircraft laboratory, Wright Field, Dayton, Ohio, the monocoque fuselage consists of laminated resin-impregnated fiberglas faces and balsa-wood core. When tested, the strength-weight ratio of the sandwich-type monocoque fuselage was impressively superior to that of the ribbed or reinforced metal fuselage. Also at ultimate failure, the plastic specimen showed no disruption of its smooth contour whereas the metal counterpart was noticeably disfigured by deep shear and compression wrinkles.

If it were possible to distribute the weight of material in every segment of a structure so as to include just enough sectional area required to support the maximum load action upon it at the design condition, airplanes could be built far more efficiently than they are today. For example, let us take a wing panel as a good illustration. The designer knows well the conditions which he is required to meet. Calculating the bending, shear, and torsional load on the wing panel, he must estimate the area and section modulus of the material necessary to support the air loads acting upon the exterior surfaces. The bending moments determine the net area of material to be distributed in the upper and lower surfaces. Likewise, horizontal and torsion shear stresses dictate the minimum gage of wing-surface skins. Inasmuch as unsupported thin-metal panels cannot carry air loads, means are provided to reinforce sectional areas. For this purpose stringers are added to stiffen the skin, ribs to distribute air loads from the skin to vertical spar webs, spars to transfer normal shear loads to the fuselage attachments and spar caps, and stringers to act as compression and tension members for bending loads.

An ideal thin-metal structure is one that possesses just enough section-area material to support the maximum loads imposed on it and yet maintain a reasonable margin of safety and no more. This is seldom, if ever, the case with present conventional wing design. Due to conditions over which the designer has very little control, the ratio of available strength of material present to that required to resist loads in the wing will vary from approximately 5.0 per cent at the root section to as much as 400 per cent at the wing tip. In other words, a wing is usually just strong enough to hold the ultimate design load at the root section, but becomes progressively overstrength outboard to the tip section. Some factors

Contributed by the Rubber and Plastics Division and presented at the Aviation War Conference, Los Angeles, Calif., June 11–14, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

TABLE I - AVERAGE PROPERTIES [a] - Sheets, Nominal Thickness, 1/4 In. *

Property	Direction of Load	Resin A OC-64 Cloth	Resin B OC-64 Cloth	Resin C OC-64 Cloth	Resin D OC-64 Cloth
Tension, p.s.i.	Longitudinal	50,730	47,720	48,560	44,910
	Transverse	39,900	42,820	44,120	39,750
	45°	13,690	14,000	19,140	13,730
Compression, p.s.i.	Longitudinal	43,230	40,540	48,000	40,410
	Transverse	31,680	40,740	41,620	46,540
	45°	16,300	17,490	20,400	21,110
Flexure, p.s.i.	Longitudinal	63,150	61,900	61,150	62,500
	Transverse	48,100	59,000	49,700	55,300
	45°	26,500	28,350	33,850	29,150
Modulus of elasticity, p.s.i. (tension)	Longitudinal	2.33×10^6	2.24×10^6	2.27×10^6	2.00×10^6
	Transverse	1.86×10^6	2.02×10^6	2.05×10^6	1.83×10^6
(flexure)	Longitudinal	2.97×10^6	2.64×10^6	2.51×10^6	2.64×10^6
	Transverse	2.27×10^6	2.11×10^6	1.89×10^6	1.79×10^6
	45°	1.05×10^6	0.95×10^6	0.79×10^6	0.97×10^6
Proportional limit, psi. (flexure)	Longitudinal	24,500	23,800	31,000	23,800
	Transverse	15,400	11,300	18,400	23,500
	45°	5,730	6,800	6,000	4,660
Coeff. thermal exp., cm./cm./°F	Longitudinal	6.9×10^{-6}	5.1×10^{-6}	8.6×10^{-6}	6.6×10^{-6}
	Transverse		7.4×10^{-6}	9.7×10^{-6}	9.0×10^{-6}
Water absorption, %	.....	0.6	0.3	0.4	0.6
Hardness, Rockwell M	.....	110	111	110	115
Chemical resistance, %					
Aviation gasoline, weight increase	.....	-0.1	0.0	-0.1	-0.1
Prestone, weight increase	.....	-1.9	0.0	0.0	0.1
Flammability, burning rate, in. per min.	.....	Self-extinguishing	0.247	0.271	Self-extinguishing
Glass content, % (by weight)	.....	60.8	53.1	52.3	49.2
(by volume)	.....	39.2	39.5	39.7	35.9
Specific gravity	.....	1.71	1.78	1.81	1.73

[a] The above properties have been determined by means of procedure outline in L-P-406 Federal Standard Stock Catalog, Section IV, Part 5, "Federal Spec. for Plastics, Organic; General Specs. (Method of Tests.)"

such as the following, indigenous to metal fabrication and design, contribute to the conditions stated:

An appreciable amount of weight could be saved if the surface sheets were tapered in gage spanwise along the wing in proportion to the amount of stresses acting on it. It is customary to average the over-all thickness of wing span by using a constant-gage sheet to a given point, then abruptly reducing gage thickness from there on with a thinner sheet. Areas of spar caps and stringers are altered in the same manner.

Another feature encountered with thin-metal fabrication which tends to introduce a weight penalty is the instability of gages of 0.032 or under to riveting and so-called "oil-canning." Aerodynamically, it is extremely important to keep the wetted area of the wing free of protruding rivet heads, lap joints, and surface irregularities, such as dents. Hence thin sheet-metal surfaces become difficult to work when flush-riveting of smooth contours is essential, since thin skins are apt to creep and deform under riveting forces. Furthermore, the surface sheet, although it may be strong enough to carry parallel loads, will deflect or wrinkle badly under air load, thus creating disturbing aerodynamic characteristics. Consequently, a thicker sheet than is normally needed to resist stresses is employed because of these limitations. Yet another troublesome condition, which is part of the design of thin-metal structures, is the inability to use all of its sectional area to support bending loads. Inasmuch as an unstiffened thin panel cannot be loaded axially without buckling, only certain portions of it can be used or considered to act along with the spar caps and stringers in bending. Design criteria allow $30t^2$ of surface skin adjacent to the compression areas to remain effective against compression buckles. The other portion of the unstiffened skin between stringers becomes ineffective once buckling starts. Thus an efficient wing is deemed one which maintains a smooth surface free from wrinkles throughout all flight conditions, consists of just enough stressed material to support design loads with an over-all margin of safety of no more than 15 per cent, and is essentially monocoque in structure in order to facilitate production and reduce man-hours and costs.

RELATIVE PROPERTIES AND DESIGN CRITERIA OF HIGH-STRENGTH CORED PLASTICS AND ALUMINUM MATERIALS

For the sake of illustration, let us compare the stressed-skin structure typical of thin-metal semimonocoque wings and that of a pure plastic monocoque wing. In so far as the plastic wing is concerned, it is to be a pure monocoque body. There are to be no stringers, stiffeners, ribs, and auxiliary spars. It is assumed that the vertical shear is carried by the leading edge and a small percentage by the false spar or flap-and-aileron-attachment spar. This assumption is consistent with good design since several flying airplanes have been built having wings minus outer panel spars. To provide skin stiffness and therefore a true and constant airfoil contour at all conditions of flight, a sandwich-type structure will be employed. The sandwich section will possess enough material to resist normal and torsional shear stresses and all bending stresses. A further purpose of a plastic monocoque wing will be to save

TABLE I - AVERAGE PROPERTIES [a] - Sheets, Nominal Thickness, 1/4 In * (cont'd)

Property	Direction of Load	Resin E OC-64 Cloth	Resin F OC-64 Cloth	Resin G[b] OC-64 Cloth	Resin H[b] ECC-11-112 Cloth
Tension, psi	Longitudinal	46,270	46,400	54,720	43,360
	Transverse	42,580	43,960	45,740	43,060
	45°	14,810	14,390	19,570	24,370
Compression, psi	Longitudinal	51,030	46,670	54,180	36,570
	Transverse	47,160	44,540	56,820	39,520
	45°	17,740	16,830	27,930	23,400
Flexure, psi.	Longitudinal	72,500	71,150	84,600	45,350
	Transverse	65,850	63,750	62,600	50,700
	45°	26,850	27,900	40,920	34,880
Modulus of elasticity, psi (tension)	Longitudinal	2.16×10^6	2.10×10^6	2.49×10^6	2.18×10^6
	Transverse	1.98×10^6	2.00×10^6	2.13×10^6	2.19×10^6
(flexure)	Longitudinal	2.71×10^6	2.67×10^6	2.98×10^6	2.32×10^6
	Transverse	2.19×10^6	1.82×10^6	2.34×10^6	2.45×10^6
	45°	1.13×10^6	0.78×10^6	1.36×10^6	0.26×10^6
Proportional limit, psi (flexure)	Longitudinal	15,710	28,600	32,250	
	Transverse	15,760	15,900	21,100	
	45°	18,750	9,600	15,100	10,500
Coeff. thermal exp., cm./ cm./°F.	Longitudinal	7.7×10^{-6}	7.8×10^{-6}	8.2×10^{-6}	8.5×10^{-6}
	Transverse	9.7×10^{-6}	8.5×10^{-6}	8.9×10^{-6}	7.3×10^{-6}
Water absorption, %	.....	0.3	0.5	0.4	
Hardness, Rockwell M	.....	115	112	117	119
Chemical resistance, %					
Aviation gasoline, weight increase	.....	0.0	-0.2	1.23	
Prestone, weight increase	.....	0.1	-0.1	0.77	
Flammability, burning rate, in. per min.	.....	0.251	Self-extin guishing	0.4	Self-extin guishing
Glass content, % (by weight)	.....	54.2	54.7	53.4	54.7
(by volume)	.....	37.9	40.8	39.2	41.2
Specific gravity	.....	1.69	1.77	1.76	1.78

[a] The above properties have been determined by means of procedure outline in L-P-406 Federal Standard Stock Catalog, Section IV, Part 5, "Federal Specification for Plastics, Organic; General Specs (Method of tests)." [b] Flaked fibers omitted.
* Taken from Modern Plastics May 1944 Vol. 21, No. 9, pp. 89-112,184.

weight and to offer production advantages over that of the stressed-skin semimonocoque metal wing. To accomplish this, the plastic material will need to have strength comparable to that of aluminum alloy.

Table 1 is included to show some basic mechanical properties of high-strength plastic, namely, resin-impregnated-fiberglas lamination. It will be noticed that tensile and compression values vary between 44,000 and 54,000 psi, depending on the type of cloth and resin used. Tensile values of 100,000 psi have been obtained with unidirectional fiberglas. On the other hand, 24S-T aluminum is good for 60,000 psi in ultimate tension and compression. However, flexure values of between 60,000 and 80,000 psi are greater for the plastic material than 45,000, which corresponds to the average allowable for 24S-T aluminum.

Again, it is to be noted that the modulus of elasticity of aluminum is 10,000,000 whereas that for the glass-reinforced plastic is around 2,000,000 to 2,500,000. In some instances values of 5,000,000 have been reported for reinforced plastic material. Several properties not noted here are allowable bearing and shear values. The average bearing and shear are known to be approximately 30,000 psi and 15,000 psi, respectively. These are considerably lower than those given for the aluminum alloys which are 90,000 psi and 33,000 psi, respectively, for the same properties. The discrepancies in the relative strengths of the two materials are of no disadvantage to a sandwich-type structure; for unlike metals, plastic-sheet material can be laminated in a tapering section, thus utilizing the effective efficiency of the sheet. Unlike metals, a core comprising low-density substance may be combined with high-strength plastic facing sheets to produce a greater moment of inertia than it is possible to obtain with a stiffened metal panel for the same weight per unit length of span. These factors contribute to the realization of a pure-monocoque-shaped shell.

In the preliminary design of a plastic wing in which a sandwich-type structure is concerned, one of the most important factors to be considered is the mutual support of the core and facing materials. To develop the ultimate material strength of the facing sheet in edgewise compression, every unsupported segment needs to be restrained to prevent elastic instability or buckling. For this purpose, a lightweight synthetic-core material is sandwiched between the outer faces of high-strength plastic sheets. The structural efficiency of this type of assembly depends entirely on the properties of the core. The most critical properties are compression, tension, and shear rigidity.

Normally, the exposed surface of a wing is subjected to air loads which tend to load the skin in tension or compression according to the position of the wing in various flight conditions. Hence with a sandwich-type structure, the bond between the face and core in tension must be sufficient to distribute load normal to the surface to either face sheet. Furthermore, column load introduced into the structure parallel to the faces, due to bending deflections, should not cause local compression failures in the core before the face material is fully loaded to its ultimate design load. Finally, the transfer of horizontal shear loads from one face to another should be

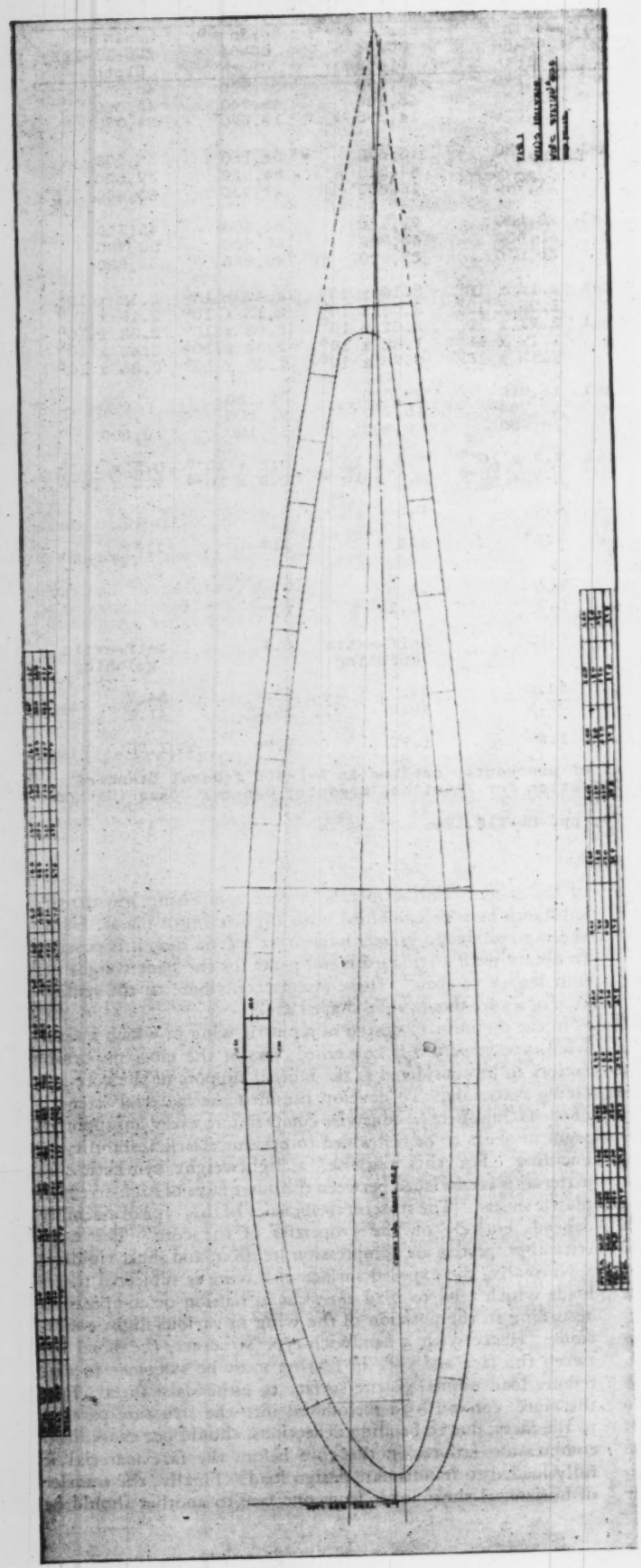

FIG. 1 CROSS SECTION OF TUBULAR-TYPE MONOCOQUE WING

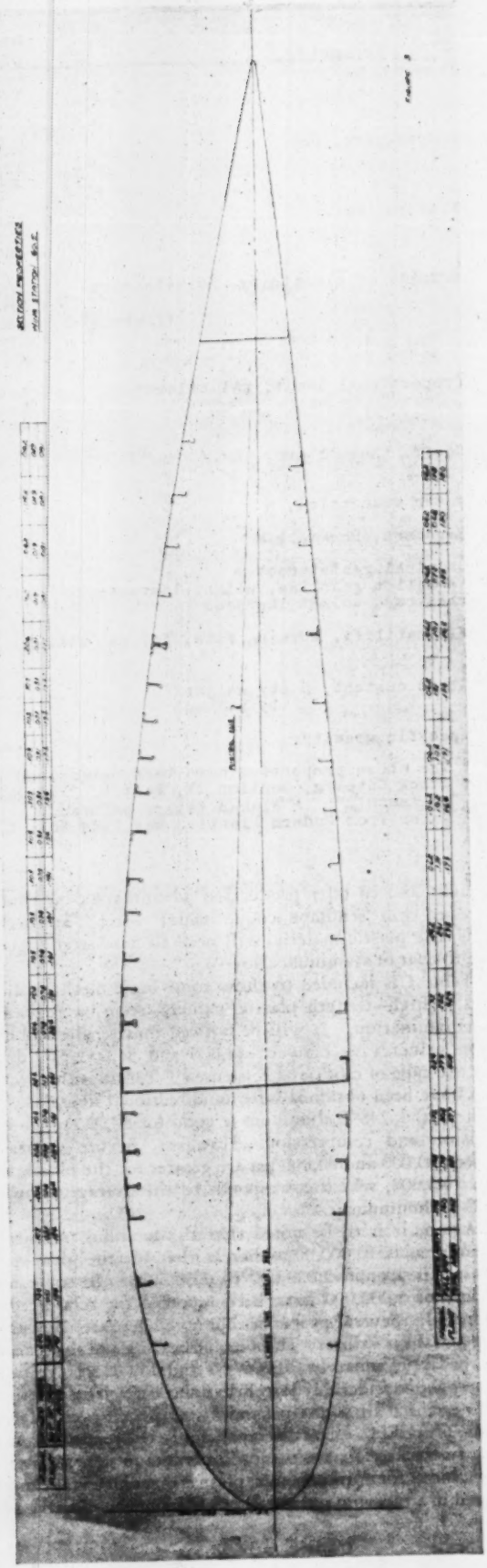

FIG. 3 SECTIONAL VIEW OF METAL WING

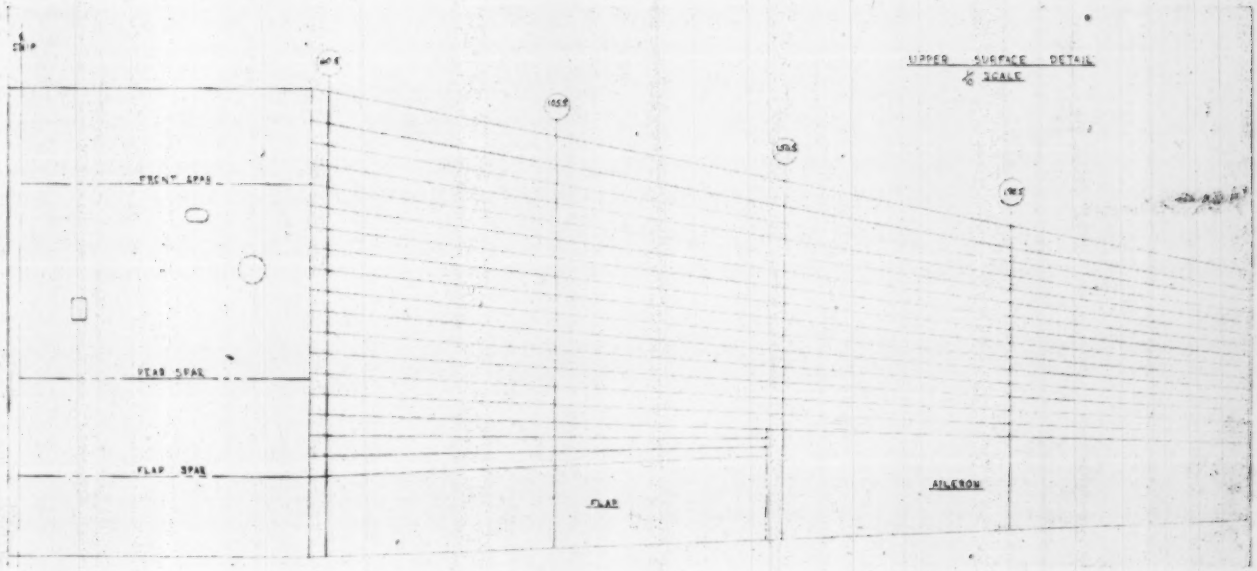

FIG. 2 PLAN VIEW OF OUTER-WING PANEL

accomplished without shear deformation or failure of the core.

Thus, keeping these critieria in mind, a wing design comprising a cored multitubular-type shell is proposed in lieu of a typical metal wing in an effort to show the advantages inherent in a low-pressure molded-plastic structure, namely, reduction of weight, man-hours, and tooling. To make a direct comparison between a stressed-skin reinforced metal body and a sandwich-type monocoque plastic counterpart, the outer wing panel of the North American AT-6 trainer will serve as an interesting example. Another reason why in this case it is pertinent to select the AT-6 wing as a specimen is primarily because of the fact that vast amounts of data, accumulated in the form of stress and test reports, are available. This particular wing has been constructed of aluminum, wood, magnesium, and steel for purposes of experimentation.

Much thought and work have been given to low-density materials. Probably the first attempt to incorporate lightweight substances between faces of high-strength materials was done with balsa wood or related products. In certain instances, balsawood cores have been considered quite satisfactory. The British have been very successful with wood-fiber cores. In this country various attempts have been made from time to time to use balsa in the construction of monocoque and semimonocoque structures. But on the whole, the consensus of opinion is that the moisture-absorption properties of balsa are detrimental to the general over-all dimensional stability of a sandwich class of structure. As a result, the trend is definitely toward a resinous expanded or foamed product, or a mechanically constructed, honeycombed or webbed system having equal or better strength properties, lower specific gravity, and which is dimensionally more stable than balsawood.

In this connection, foamed thermoplastics and thermosetting resins have been made weighing less than 3 lb per cu ft, which are able to resist a surprising amount of compression and tension loading. A recent experiment with a foamed polyester-modified styrene resin produced samples weighing between 6 and 7 lb per cu ft that withstood a compression load of 125 psi before slight crushing of the section occurred. Hence the availability of strong lightweight core materials, suitable for efficient sandwich construction, is no longer a matter of conjecture. There are some already deemed satisfactory based on the findings of experimentation and test data. However, in so far as is known at this time, exhaustive or conclusive data are not available. Hence, in view of the incompleteness of knowledge and data concerning these materials, a lightweight core having a specific gravity of 0.08 or density of 5 lb per cu ft will be selected for the design of the plastic monocoque wing to be described.

DESIGN AND STRESS ANALYSIS OF PLASTIC COUNTERPART OF METAL AT-6 OUTER WING PANEL

A design proposing the construction of a finished article must have as its basis manufacturing practicability. Especially must it offer more advantages than other processes of manufacture if it is intended to secure a satisfactory reception for immediate or future adoption. The plastic wing offers this advantage. It is estimated that the man-hours expended in the fabrication of a conventional wing is approximately 1000 to 3000, depending on the size and complexity of design. The low-pressure-molding of a plastic wing can be achieved in substantially less than 1000 man-hours. It would not be beyond the realm of possibility to build the subject plastic wing in less than 100 man-hours.

In Fig. 1 is shown a cross-sectional view of what may be considered a practical and efficient design of a tubular-type monocoque wing which functions structurally without the benefit of spars, ribs, or stringers. From the standpoint of production, the tooling and method necessary to laminate or mold a wing as shown is not as difficult as appears on the surface. Utilizing the bag-molding principle, characteristic of the low-pressure molding process, the plastic wing can be shaped in one complete operation, and on and in one set of molds.

This is particularly advantageous since it reduces the number of tools and assembly jigs necessary to the accurate assembly of component parts. In this case a vented mandrel, piped for compressed air, is to be encased in a rubber blanket. Layers of impregnated glass fabric are laminated around the pressure mandrel and covered completely by a female mold. It would be practical to cast the female mold in sections of such a mate-

TABLE 2 BENDING STRESSES FOR ROOT STATION 60.5 AND OUTER-WING-PANEL STATION 195.5

BENDING STRESS NORMAL FLIGHT

WING STATION 60.5

ITEM	X_p	Y_p	4528 Y_p	105.09 X_p	STRESS
1	-31.875	2.593	11.710	-3.358	15.068
	-31.500	1.875	8.499	-3.318	11.817
	-31.093	1.187	4.920	-3.260	8.180
2	-28.	4.078	18.480	-2.941	-21.421
	-27.750	3.512	14.999	-2.919	-17.918
	-27.515	2.625	11.898	-2.891	-14.789
3	-24.062	5.125	23.198	-2.524	-25.722
	-23.890	4.375	19.800	-2.518	-22.318
	-23.718	3.625	16.420	-2.496	-18.916
4	-20.062	5.781	26.147	-2.120	-28.317
	-19.984	5.	22.540	-2.100	-24.740
	-19.875	4.250	19.230	-2.099	-21.349
5	-16.031	6.187	27.999	-1.686	-29.685
	-16.	5.437	24.599	-1.682	-26.281
	-15.968	4.687	21.200	-1.678	-22.878
6	-12.031	6.468	29.298	-1.263	-30.561
	-12.	5.687	25.715	-1.261	-26.976
	-11.984	4.937	22.370	-1.259	-23.629
7	- 8.015	6.609	29.912	- .842	-30.854
	- 8.015	5.812	26.380	- .842	-27.222
	- 8.015	5.062	22.990	- .842	-23.832
8	- 3.984	6.593	29.810	- .419	-30.229
	- 4.015	5.843	26.410	- .421	-26.831
	- 4.031	5.062	22.990	- .423	-23.413
9	- .046	6.531	29.598	- .48	-29.601
	- .046	5.765	26.100	- .48	-26.106
	- .046	4.984	22.590	- .48	-22.594
10	+ 3.937	6.375	28.830	+ 4.136	-24.417
	3.906	5.593	25.300	4.10	-21.890
	3.875	4.812	21.799	4.067	-21.393
11	7.937	6.125	27.790	8.348	-26.955
	7.906	5.375	24.390	8.309	-23.499
	7.875	4.562	20.640	8.266	-19.813
12	11.937	5.812	26.890	12.58	-25.132
	11.906	5.062	22.930	12.51	-21.379
	11.875	4.250	19.250	12.48	-18.002
13	15.937	5.484	24.809	16.76	-23.133
	15.875	4.750	21.510	16.68	-19.842
	15.781	3.937	17.800	16.58	-16.142
14	19.875	5.062	22.640	20.85	-20.535
	19.812	4.312	19.502	20.81	-17.421
	19.734	3.562	16.138	20.76	-14.062
15	23.875	4.656	21.097	25.13	-18.584
	23.812	3.906	17.698	25.04	-15.144
	23.734	3.125	14.340	24.96	-11.844
16	27.812	4.187	18.910	29.23	-15.987
	27.750	3.437	15.548	29.18	-12.630
	27.656	2.125	9.630	29.04	- 6.726
17	31.875	3.625	16.410	33.52	-13.058
	31.781	2.875	13.010	33.36	- 9.672
	31.687	2.125	9.630	33.29	- 6.301

WING STATION 195.5

ITEM	X_p	Y_p	1998 Y_p	35.58 X_p	STRESS
1	-15.250	1.937	- 3861	- 542	- 4403
	-15.078	1.562	- 3120	- 536	- 3656
	-14.984	1.203	- 2400	- 533	- 2933
2	-12.781	2.625	- 5249	- 454	- 5703
	-12.687	2.250	- 4490	- 450	- 4920
	-12.593	1.875	- 3741	- 446	- 4187
3	-10.296	3.187	- 6362	- 365	- 6727
	-10.234	2.812	- 5617	- 364	- 5981
	-10.156	2.437	- 4858	- 361	- 5219
4	- 7.828	3.515	- 7017	- 278	- 7295
	- 7.781	3.187	- 6360	- 276	- 6636
	- 7.750	2.781	- 5557	- 275	- 5832
5	- 3.312	3.796	- 7575	- 189	- 7764
	- 3.281	3.421	- 6828	- 188	- 7016
	- 3.250	3.031	- 6051	- 186	- 6237
6	- 2.843	3.968	- 7938	- 101	- 8035
	- 2.812	3.593	- 7168	- 100	- 7268
	- 2.812	3.187	- 6360	- 100	- 6460
7	- .312	4.046	- 8058	- 112	- 8069
	- .312	3.687	- 7360	- 112	- 7372
	- .281	3.312	- 6617	- 10	- 6628
8	+2.171	4.046	- 8058	+ 86	- 7972
	2.156	3.656	- 7291	85	- 7206
	2.140	3.281	- 6.554	84	- 6470
9	4.640	4.	- 7992	165	- 7827
	4.640	3.625	- 7249	166	- 7083
	4.640	3.250	- 6499	165	- 6334
10	7.109	3.937	- 7850	252	- 7598
	7.109	3.593	- 7160	252	- 6908
	7.093	3.187	- 6371	252	- 6119
11	9.625	3.843	- 7690	342	- 7348
	9.578	3.500	- 6990	341	- 6644
	9.562	3.062	- 6120	340	- 5780
12	12.078	3.687	- 7368	429	- 6939
	12.062	3.328	- 6649	428	- 6221
	12.046	2.937	- 5857	426	- 5431
13	14.562	3.468	- 6940	517	- 6423
	14.546	3.109	- 6201	516	- 5685
	14.515	2.687	- 5369	515	- 4854
14	17.062	3.218	- 6418	605	- 5813
	17.	2.828	- 4652	604	- 4040
	16.968	2.437	- 4852	603	- 4244

ITEM	X_p	Y_p	4528 Y_p	105.09 X_p	STRESS
1	-29.843	-5.	22.640	-3.139	19.501
	-29.815	-5.734	25.950	-3.140	22.810
	-29.984	-6.500	29.390	-3.142	26.248
2	-23.843	-5.390	24.810	-2.510	22.300
	-23.906	-6.187	27.998	-2.518	25.480
	-23.921	-6.984	31.598	-2.514	29.079
3	-17.875	-6.531	25.100	-1.879	23.221
	-17.890	-6.312	28.560	-1.880	26.680
	-17.890	-7.062	31.640	-1.880	29.760
4	-11.812	-5.484	24.798	-1.240	23.558
	-11.812	-6.250	28.240	-1.240	27.000
	-11.812	-7.031	31.630	-1.240	30.390
5	- 5.875	-5.250	23.780	- 6.179	17.601
	- 5.859	-6.015	27.190	- .616	26.574
	- 5.781	-6.781	30.660	- 6.078	30.052
6	+ .109	-4.875	22.080	+ 11.4	22.091
	.187	-5.625	25.425	196	25.444
	.250	-6.375	28.816	26	28.841
7	6.093	-4.312	19.498	6.318	20.129
	6.187	-5.093	23.610	650	23.260
	6.250	-4.437	20.090	657	20.747
8	12.125	-3.687	16.698	1.275	17.973
	12.187	-4.437	20.090	1.279	21.369
	12.312	-5.187	23.425	1.298	24.723
9	18.062	-2.937	13.289	1.897	15.186
	18.187	-3.734	16.887	1.910	18.797
	18.250	-4.500	20.190	1.919	22.109
10	24.062	-2.234	10.099	2.522	13.621
	24.156	-2.984	13.500	2.538	16.038
	24.250	-3.015	13.595	2.532	16.127
11	30.031	-1.453	6.580	3.159	9.739
	30.125	-2.250	10.197	3.162	13.359
	30.250	-3.	13.584	3.180	16.764

$\frac{M_{WP}}{I_{XP}} = \frac{1,141,260}{232\,118} = 4528$

$\frac{M_{WP}}{I_{YP}} = \frac{356,780}{3398.806} = 105.09$

$\frac{M_{WP}}{I_{XP}} = \frac{73,692}{36,904} = 1998.0$

$\frac{M_{WP}}{I_{YP}} = \frac{14,530}{409.02} = 35.58$

① STA.	② θ	③ COS θ	④ SIN θ	⑤ M_W	⑥ M_W COS θ	⑦ M_W SIN θ	⑧ M_L	⑨ M_L COS θ	⑩ M_L SIN θ	⑪ M_{WP} / 2.10	⑫ M_{LP} / 7.99
60.5	-4° 22.5	.997	-.0762	1,164,662	1,161,400	-88,680	-268,846	-268,100	-20,340	1,141,260	-336,780
105.5	-1° 49.5	.9995	-.0317	630,740	630,524	-19,994	-137,980	-137,911	-4,448	626,081	-153,917
150.5	-1° 48.3	.9995	-.0316	274,481	273,999	-8,634	-53,544	-53,501	-1,681	272.318	-62,135
195.5	-2° 46	.996	-.0482	74,274	74,220	-3,580	-10,973	-10,950	-528	73,692	-14,530

rial as kirksite, bolting and sealing them in the upper and lower halves of the exterior mold. The mandrel could be wood, masonite, or any cheap material readily machined to the desired shape. To clarify the complete operation, it might not be amiss if a step-by-step procedure were outlined, as follows:

Referring again to the sectional wing view, Fig. 1, lower sketch, it will be noticed that the inner skin of each tube segment is 0.020. The vertical webs, of which there are more in the upper surface than the lower, are also 0.020. The outer skin, however, is 0.040. A fiberglas cloth of ECC-128 classification is approximately 0.010 in. thick when impregnated with a convenient low-viscosity resin. One complete wrap of the rubber-covered mandrel produces one half of the inner-skin thickness. A light core material of 5 lb per cu ft is machined and tapered spanwise to the inside of the tube dimensions as shown. The cores are also individually wrapped spanwise with one layer of ECC-128 impregnated cloth and located in their respective positions on the covered mandrel. Then two layers of the same cloth are wrapped over the whole assembly to give the gage of surfaces and vertical webs described. The final operation consists of covering the assembly with the mold halves which are heated by electrical elements, referred to as strip heaters, clamping in an airtight closed position, and exerting internal pressure by means of air valves connected to the mandrel. Upon curing to the desired state, the mold is opened and the tapered mandrel is extracted from the open end of the wing panel.

It was mentioned in an earlier part of the paper that the leading edge of the wing was structurally strong enough to carry the normal shear load. This is true. However, an individual vertical web of each adjacent tube is capable and will transmit shear load spanwise to the wing joint. Inasmuch as approximately 70 per cent of the total lift of a wing is obtained on the upper surface, there are more webs in this surface than are to be found in the underneath side. Hence stress analysis, based on the conditions just stated, were prepared to determine the feasibility of such a design from the standpoint of strength and weight.

Fig. 2 is a plan view of the outer wing panel on which are noted the number of tubes and outer-skin gages at four stations, selected for purpose of analysis.

Table 2 includes bending stresses for the root station 60.5 and outer-wing-panel station 195.5. Preliminary calculations necessary to obtain these data take up more space than can be allotted herein and therefore are excluded. For the same reason, bending stresses at stations, other than those previously noted, are also excluded.

In Table 3 are to be found the bending stresses for the reinforced metal wing, as taken from North American Report No. NA-999. For purposes of comparison of design, a wing-section view of the metal wing at station 60.5 is included in Fig. 3.

Examination of the table of bending stresses will disclose a maximum compression stress of 30,834 psi in the upper surface and 30,391 psi tension stress in the lower surface at station 60.5. According to the ultimate flexural stress for fiberglas-reinforced plastics, the allowable stress is between 61,000 and 84,000 psi (see Table 1). This, of course, is based on block compression wherein the skin is perfectly stabilized. In the subject plastic design, the stresses are sufficiently low so that the stabilizing effect of the core could almost be ignored, especially in view of the mutual stiffness and support of the multitubular construction. In effect then, the greatest usefulness of the core is to provide compression backing for the original molding pressure which may be as much as 100 psi.

The last section analyzed at station 195.5 shows maximum bending stresses of 8070 psi in compression. While this stress

TABLE 3 BENDING STRESSES FOR REINFORCED METAL WING

BENDING STRESSES
WING STATION 60.5

			H.A.A.			LAA		
Item	y_p	x_p	4330 y_p	222.8 x_p	STRESS	4679 y_p	95.2 x_p	STRESS
1	4.30	-25.53	-19,480	-5,960	-25,170			
2	5.06	-21.80	-22,920	-4,860	-27,780			
3	5.66	-17.60	-25,640	-3,920	-29,560			
4	5.88	-15.75	-26,640	-3,510	-30,510			
5	6.04	-13.57	-27,360	-3,020	-30,380			
6	6.16	-11.25	-27,900	-2,510	-30,410			
7	6.22	-9.21	-28,180	-2,050	-30,230	-29,100	- 880	-29,980
8	6.34	-5.50	-28,720	-1,230	-29,950	-29,660	- 520	-30,180
9	6.30	-3.45	-28,540	- 770	-29,310	-29,480	- 330	-29,810
10	6.30	-1.40	-28,540	- 310	-28,850	-29,480	- 130	-29,610
11	6.22	+1.37				-29,100	+ 130	-28,970
12	6.16	3.45				-28,820	330	-28,490
13	5.96	6.45				-27,890	610	-27,280
14	5.80	9.14				-27,140	870	-26,270
15	5.62	11.35				-26,300	1080	-25,220
16	5.44	13.61				-25,450	1300	-24,150
17	5.24	15.65				-24,520	1490	-23,030
18	5.02	18.30				-23,490	1740	-21,750
19	4.80	21.33				-22,460	2030	-20,430
20	4.48	24.45				-20,960	2330	-18,630
21	4.10	27.71				-19,180	2640	-16,540
22	3.70	31.10				-17,310	2960	-14,350
25	-6.72	-17.07				+31,440	-1630	29,810
26	-6.72	-13.99				31,440	-1330	30,110
27	-6.70	-11.20				31,350	-1070	30,280
28	-6.42	-8.32				30,040	- 790	29,250
29	-6.50	- 4.38				30,410	- 420	29,990
30	-6.18	+ .01	27,990	0	27,990	-28,920	0	28,920
31	-5.80	6.05	26,270	1350	27,620	27,140	580	27,720
32	-5.50	9.35	24,910	2080	26,990	25,730	890	26,620
33	-5.12	11.25	23,190	2510	25,700			
34	-4.72	16.06	21,380	3580	24,960			
35	-4.30	20.30	19,480	4520	24,000			
35a	-3.82	21.87	17,300	4870	22,170			
36	-3.50	24.60	15,850	5480	21,330			
37	-3.22	27.29	14,590	6080	20,670			
38	-2.94	29.73	13,320	6620	19,940			

BENDING STRESSES
WING STATION 195.5

ITEM	y_p	x_p	3334 y_p	458 x_p	STRESS	3362 y_p	9.7 x_p	STRESS
1	3.47	- 14.62	-11,570	-670	-12,240			
2	4.21	- 10.63	-14,040	- 490	-14,530			
5	4.62	- 6.60	-15,400	- 300	-15,700	-15,530	- 60	-15,590
7	4.56	- 3.52	-15,200	- 160	-15,360	-15,330	- 30	-15,360
9	4.65	+ .82	-15,500	+ 40	-15,460	-15,630	+ 10	-15,620
12	4.35	4.80	-14,500	220	-14,280	-14,620	50	-14,570
15	4.00	10.00	-13,340	460	-12,880	-13,450	100	-13,350
18	3.40	14.62	-11,340	670	-10,670	-11,430	140	-11,290
20	2.72	19.55	-9,070	900	-8,170	-9,140	190	-8,950
23	-2.50	- 14.60	8330	-670	+7,660	8400	-140	8260
24	-2.61	- 11.50	8700	-530	8,170	8770	- 110	8660
26	-2.62	- 7.55	8730	-350	8,380	8810	- 70	8740
28	-2.47	- 3.45	8230	-160	8,070	8300	- 30	8270
30	-2.40	+ 1.94	8000	+ 90	8,090	8070	+20	8090
31	-2.30	4.90	7670	220	7,890	7730	+50	7780
33	-2.12	9.20	7070	420	7,490			
35	-1.88	14.50	6270	660	6,930			
36a	-1.68	19.35	5600	900	6,500			

TABLE 4 DATA FOR CALCULATING WEIGHT PER UNIT LENGTH OF SPAN OF PLASTIC WING

Station	t_o	t_i	t_w	Depth of Core	Circ. Outside	Circ. Inside	Number of Webs	Ave. Circ. Core	Wt. of Outer Skin	Wt. of Inner Skin	Wt. of Core	Wt. of Webs	Total Wt. in Span
60.5	.040	.020	.020	1.50	155	140	30	148	.4040	.1820	.6450	.0585	1.29 #/in.
105.5	.035	.020	.020	1.25	135	126.5	30	130.8	.3080	.1645	.4750	.0486	.9961 #/in.
150.5	.030	.020	.020	1.00	110.3	104	30	107.2	.2150	.1450	.3100	.0390	.6990 #/in.
195.5	.025	.020	.020	.75	89.5	83.25	25	86.4	.1480	.1080	.1880	.0245	.4685 #/in.

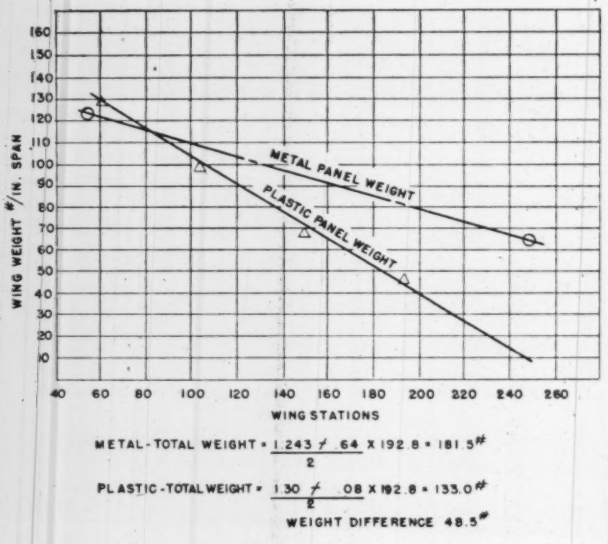

FIG. 4 COMPARISON OF UNIT WEIGHTS OF METAL OUTER WING PANEL, AND PLASTIC PROTOTYPE

is very small compared with the allowable ultimate, the skins, being 0.025 and 0.020 for the outer and inner surfaces, respectively, are more dependent upon the core for stabilization. All values listed, however, are very low, which may be taken as a sign of efficient distribution of bending material. Furthermore, the results are indicative of greater possibility for refinement of design to obtain better results than are shown here.

So far it has been pointed out that a reduction of tools, fixtures, and manufacturing man-hours may be secured if a plant is properly set up to produce plastic wings. In addition, one of the most important contributions to the efficient performance of aircraft is obtainable by a reduction of normal gross weight. Table 4 includes the data for calculating the weight per unit length of span of the plastic wing. The skin gages and depth of core materials noted therein are the same used in the sectional properties for the calculation of bending stresses discussed previously.

Fig. 4 consists of a plot of the unit weights of both the metal and plastic outer wing panel. As a point of interest, it is to be pointed out that while the plastic unit weight per inch of span at station 60.5 is slightly greater than the metal wing, there is a considerable drop and deviation at the end station. On the basis that all efficient structures should be just strong enough to support the ultimate design load imposed upon them without failure, it can be seen that the plastic distribution of material is more conducive to an optimum weight saving. Calculating the total weight of the metal wing which is 181.5 lb and that of the plastic counterpart which is 133 lb, a net saving of weight equal to 48.5 lb can be obtained.

CONCLUSION

In conclusion, it must be remembered that the method of fabrication by low-pressure molding is a fairly recent development and consequently a comparatively crude one as compared with the techniques developed for metal fabrication. Furthermore, the aircraft industry, being trained in the handling and processing of light alloys, is strictly metal-minded. Therefore, knowing little about a process as foreign to them as the low-pressure method of fabrication, the aircraft industry as a whole will not take kindly to any proposal suggesting a change in its present system. It will take time and effort along this line and will have to be done in small steps before a job as extensive as the wing design proposed in this paper will be attempted on a production contract basis.

However, present indications point toward the actual realization of a production plastic wing someday in the near future. Maybe such a wing will not be patterned after the one suggested here. Nevertheless, if due consideration is given to the inherently useful properties of plastics, and particularly to the fact that these materials do not lend themselves to metal-design practices, it is certain to be an efficient as well as an economical one.

Steam-Launched Buzz Bomb

APPLICATION of steam propulsion in a new field has been achieved by The Babcock and Wilcox Company in perfecting a system for launching the "buzz bomb" by boiler-developed power. One of the top engineering secrets of the war, the mechanism employed was an improvement upon the German V-1 buzz bomb with which the Nazis attempted to level London and other cities.

The Germans had developed a chemical means of launching their bombs, but it involved considerable hazard to the operating crew. They never succeeded in devising a safe and reliable launching means, and reports have indicated that casualties among the German gun crews were heavy.

What the company did was to design and manufacture equipment to provide high-pressure steam in sufficient quantity to accelerate a load of 5000 lb to a velocity of 250 mph within a distance of 150 ft, the travel of the German-made ramp.

This required equipment designed for 1200 lb per sq in. pressure to handle steam at the rate of 3,000,000 lb per hr with a valve having an opening and closing time of 0.03 sec, the valve being open 0.8 sec, the time required for the bomb to travel the 150 ft of the ramp.

The equipment was built, shipped to and installed at Eglin Field, Fla., and made ready for operation by the middle of March, 1945. Trials were conducted during several months following.

During the launching, the steam equipment developed a peak of 25,000 hp, averaging 20,000 hp. The energy stored in the steam equipment, if completely released, amounted to 57,000 hp. It required only approximately 10 gallons of oil or gasoline to provide the energy for each launching.

CELLULAR PLASTICS *in* AIRCRAFT

By CARROL C. SACHS

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THE design and fabrication requirements of high-performance military airplanes have repeatedly undergone basic changes in the airframe or load-carrying structure. With the advent of the stressed-skin type of structure, the old phenomenon of compression-buckling took on a new significance.[1] As stronger light metals became available, the skin gages were repeatedly reduced until failure by compression-buckling became of first-order importance to the aeronautical engineer. One of the immediate steps which could be taken to alleviate skin-buckling was to provide periodically spaced stiffeners. This effectively decreased the panel size along which the compression load must act.

However, as design loads increase in magnitude, the type of critical failure remains the same, i.e., compression-buckling, except on a smaller panel. Where weight is an important factor in performance, as in airplane design, there is obviously a limit to the number of stiffeners which are practical. Another method of stabilizing the skins of airplanes against compression-buckling is through the adhesive attachment of a supporting core of rigid cellular plastic of low specific gravity.

It is believed that this method offers both savings in weight and in fabrication simplicity. The application should begin on lightly loaded parts, such as cabin partitions, trim tabs, and the trailing edge of the wing. As both cellular materials and fabrication techniques develop, the application to fuselage panels and the leading edge of the wing would logically follow.

Many new cellular boards have been developed recently and without doubt countless others will emerge from the laboratories. Most of these cellular boards are not new synthetic resins, but rather older materials converted into a new form. A few of the manufacturing techniques have been organized and are presented in Table 1, in order to assist the engineer in the visualization of how some of the cellular boards are produced. Most of these techniques have been borrowed from the rubber industry which has long produced both elastic and hard-rubber sponges.

THERMOPLASTIC FOAMS

The various types of thermoplastic cellular materials are best catalogued on the basis of the type and characteristics of the blowing agent used in their manufacture. Blowing agents are required to produce the cells in the plastic material and may be of the following types: (*a*) solid yielding gas, (*b*) solvents, or (*c*) soluble gas under pressure.

The oldest form of blowing agent is that of using a solid which will yield a gas. Probably the best classical example of this type of blowing is in the baking of biscuits or cakes. Either sodium carbonate or bicarbonate may be used, since both yield carbon-dioxide gas upon decomposition. A somewhat lower temperature may be employed, particularly when moisture is present, providing an organic acid such as tartaric acid or fumaric acid is present. This system yields carbonic acid which in turn decomposes into carbon-dioxide gas and water vapor. Prolonged heating not only yields carbon dioxide, but as the temperature rises, the internal pressure increases so that cell formation is facilitated.

All of the common thermoplastics may be converted into cellular materials by means of the carbonate blowing agents. Among these may be included cellulose acetate and acetate butyrate, the vinyl esters and ethers, styrene, the acrylates and methacrylates, and ethyl cellulose. Vinyl-acetal and vinyl-chloride cellular boards have been produced in England.

Each resin must be handled in a particular manner to obtain blowing in the proper portion of the viscosity - temperature curve where the resin is soft enough to be expanded by the carbon-dioxide gas liberated, but not sufficiently fluid to allow the walls of the individual cells to break through and coalesce. In other words, the resin must be capable of "holding" the gas, if small uniform cells are to be obtained.

The final size of each cell is dependent upon the crystal size of the blowing agent used and the stress-release temperature of the resin. The particles of blowing agent must be uniformly distributed within the resin, since two particles adjacent to one another result in a double-sized cell. This thorough mixing and distribution is generally achieved on hot mill rolls or in a Banbury mixer. Since the blowing agent must be introduced into the resin while the latter is in a softened or plasticized state, critical temperature control is necessary at this stage to avoid premature decomposition of the blowing agent. After the blowing agent has been fixed in the resin, the compound may be expanded by any one of several methods, as follows:

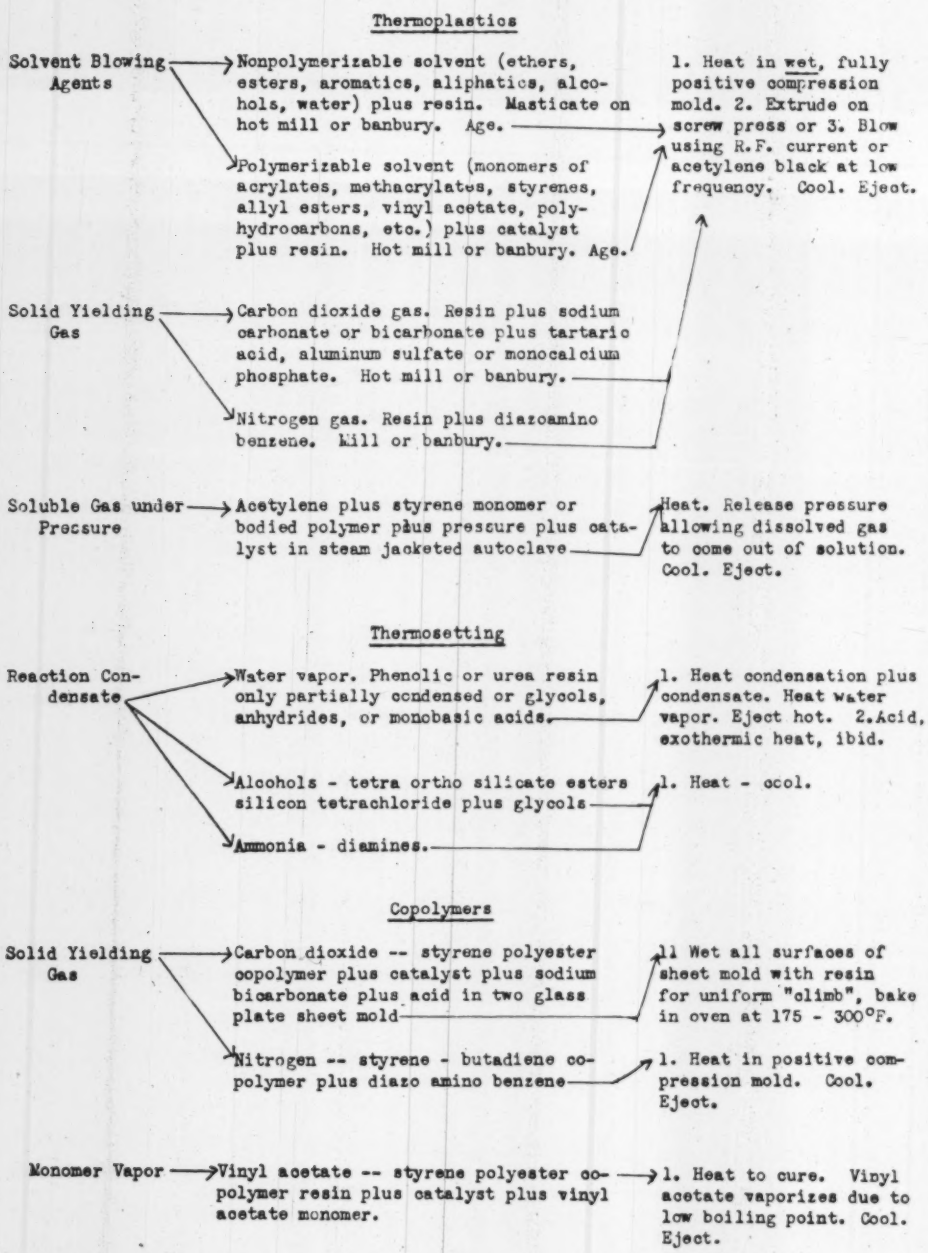
1 The compound may be introduced into a fully positive compression mold which is equipped for both heating and cooling. The charge is heated with full molding pressure applied and after the temperature has been raised sufficiently to plasticize the mass and discharge the blowing agent, the piston or force is backed slowly out of the mold cavity, and the gas which has been compressed expands, thereby forming the cellular structure. The mold is then cooled by circulating cooling water through the chase, after which the charge is ejected. If sheet stock is being formed in this manner, fabric such as canvas or fiberglas may be laid into the mold under the charge, and an adhesive bond will be accomplished during the blowing operation.

2 Another method of producing continuous cellular-strip stock is by processing the compound through a mechanical extrusion screw press where the resin is plasticized and the blowing agent is decomposed, after which the foam is shaped by extrusion through a rectangular die. The cellular-strip stock is cooled on an endless conveyer belt, after which it may be cut to the appropriate length for shipment. Needless to

[1] Compression-buckling can be visualized by the following demonstration: When a sheet of paper is grasped by either end and pulled in tension, the paper aligns itself as it becomes taut and remains in alignment until the actual tensile failure of the sheet occurs. This is not the case when pushing inward on opposite ends of a sheet of paper. Long before compression failure occurs, the sheet buckles outward to one side or the other, the net result being a configuration failure rather than a material failure in compression. After compression-buckling occurs, the sheet cannot effectively carry compression loads. Doubtless all those who have ridden in a modern air liner have noticed this phenomenon on the upper surface of the wing where it is referred to as "oil-canning." One of the costly results of such oil-canning is a premature fatigue failure of the parts involved.

Contributed by the Rubber and Plastics Division and presented at the Aviation War Conference, Los Angeles, Calif., June 11–14, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

TABLE 1 PRODUCTION SCHEME FOR RIGID PLASTIC CELLULAR MATERIALS


Thermoplastics
Solvent Blowing Agents
Nonpolymerizable solvent (ethers, esters, aromatics, aliphatics, alcohols, water) plus resin. Masticate on hot mill or banbury. Age.
Polymerizable solvent (monomers of acrylates, methacrylates, styrenes, allyl esters, vinyl acetate, polyhydrocarbons, etc.) plus catalyst plus resin. Hot mill or banbury. Age.
1. Heat in wet, fully positive compression mold. 2. Extrude on screw press or 3. Blow using R.F. current or acetylene black at low frequency. Cool. Eject.
Solid Yielding Gas
Carbon dioxide gas. Resin plus sodium carbonate or bicarbonate plus tartaric acid, aluminum sulfate or monocalcium phosphate. Hot mill or banbury.
Nitrogen gas. Resin plus diazoamino benzene. Mill or banbury.
Soluble Gas under Pressure
Acetylene plus styrene monomer or bodied polymer plus pressure plus catalyst in steam jacketed autoclave
Heat. Release pressure allowing dissolved gas to come out of solution. Cool. Eject.
Thermosetting
Reaction Condensate
Water vapor. Phenolic or urea resin only partially condensed or glycols, anhydrides, or monobasic acids.
1. Heat condensation plus condensate. Heat water vapor. Eject hot. 2. Acid, exothermic heat, ibid.
Alcohols - tetra ortho silicate esters silicon tetrachloride plus glycols
1. Heat - ocol.
Ammonia - diamines.
Copolymers
Solid Yielding Gas
Carbon dioxide -- styrene polyester copolymer plus catalyst plus sodium bicarbonate plus acid in two glass plate sheet mold
11 Wet all surfaces of sheet mold with resin for uniform "climb", bake in oven at 175 - 300°F.
Nitrogen -- styrene - butadiene copolymer plus diazo amino benzene
1. Heat in positive compression mold. Cool. Eject.
Monomer Vapor
Vinyl acetate -- styrene polyester copolymer resin plus catalyst plus vinyl acetate monomer.
1. Heat to cure. Vinyl acetate vaporizes due to low boiling point. Cool. Eject.

say, the shipment of materials having a specific gravity as low as 0.5 to 5 lb per cu ft offers problems of its own.

3 This method of expanding cellular plastic material consists of placing the charge between two sheets of aluminum which act as output electrodes to an ultra-high-frequency oscillator. The electrodes may be surface-treated in such a manner as to cause the expanding cellular core to adhere in instances where a sandwich structure is desired.

4 Yet another method of blowing cellular materials consists of milling into the compound a small percentage of acetylene black in addition to the blowing agent. This will give a high resistance, having sufficient conductivity to provide for resistance-heating at 110 v and 60 cycles.

Another solid blowing agent yielding a gas comprises the group of diazo compounds which decompose thermally, yielding nitrogen gas. One example of this family of blowing agents is diazoaminobenzene.

Thermoplastic resins may be masticated in a Banbury mixer or on heated rolls and blended with a small amount of polymerizable or nonpolymerizable solvent. After sheeting on the mill, the stock is cured or aged to the proper solvent content after which it may be expanded by any of the foregoing methods. A small amount of catalyst is also used if the liquid blowing agent is capable of polymerization. As the temperature rises, the vapor pressure of the blowing agent increases and upon release of the molding pressure forms cells in the resin. In time the small amount of liquid present polymerizes to become part of the cellular board.

The last method to be described here for expanding thermoplastic materials into cellular form consists of dissolving a

TABLE 2 PHYSICAL DATA ON EXPERIMENTALLY AVAILABLE CELLULAR BOARDS

Properties	Cellulose acetate	Styrene		Phenol formaldehyde	Buna "S" rubber		Polyvinyl chloride	Polyvinyl formal	Styrene-polyester copolymer
Density, lb per cu ft	4.1 - 6.>	1.5	5-7	7-20	4.5	9	10-20	6-30	20-30
Standard size	Strip, 2½" x 5/8" to 12'	1' x 1' x 3"	1' x 1' x 3"	2' x 1' x 1"	3' x 3' x 1"	3' x 3' x 1" or 2"	2' x 1' x ½" or 3/4"	3' x 2' x ½" of 5/8"	1' x 1' x 1"
Producer	Du Pont	Dow Chemical		General Electric	U.S. Rubber		Expanded Rubber Co.	Expanded Rubber Co.	Bakelite-Amer. Cyan. Corps.
Thermal conductivity, Btu	0.27	0.25-0.30	0.25-0.30	0.28	0.237	0.240	---	0.24	0.30
Max deg C working temp.	70	80		150 - 200	60	93	65	70-80	120
Inflammability	5.6 - 6.9 ipm D635 - 42T	Burns slowly		Does not burn	Burns	Burns	Varies with plasticizer	Burns slowly	Burns
Compression strength, psi	Ult. 41-107 2% 33-89 D695 - 42T	8-10	121-135	100	50-80	237	---	170	---
Tensile strength, psi	77C, 52-103 170C, 59-77	13-38	111-187	200	72	110	---	340	---
Modulus of elasticity:									
Compression	1600	1000	8100	4000	---	---	---	---	---
Tension	4400	1620	8000	5400	2800	3300	---	10000	---
Impact strength, ft-lb	4.1	0.76	3.5	0.1-1.34	3.0	6.5	---	2.46-3.70	0.8 - 1.5
Moisture absorption, per cent:									
60 per cent RH	2.8 - 2.9			---	---	---	---	---	---
100 per cent RH	10.4 - 10.8			---	---	---	---	---	---
Total submersion	0.87 - 1.119 in 24 hr	50 in 50 hr	3.5 in 10 days 6.67 in 500 hr	---	3.5 10 days	17 100 days	---	---	---
Relative cost per (5 lb per cu ft	$ 0.375	$ 0.30	$ 0.30	$ 0.25	$ 0.29		---	---	$ 0.375

soluble gas under pressure into a partially polymerized resin monomer (syrupy). As the resin is further polymerized, the pressure is released and the gas allowed to come out of solution forming the desired cellular structure.

THERMOSETTING FOAMS

Most thermosetting materials polymerize by the process of condensation polymerization, i.e., they become resinous by splitting out a small molecule of by-product from the two reactants. This condensate, usually water, may be vaporized to steam and utilized as a blowing agent either directly or acting indirectly upon some additive such as calcium carbide to yield acetylene gas. Phenol, urea, and furfural formaldehydes have been blown into cellular form. Thermosetting cellular boards are notably deficient in impact strength, normally being quite brittle. Unlike the thermoplastic cellular boards, the thermosetting foams cannot be easily reformed. Hence they are generally formed to the final shape during the blowing operation. Advantageous properties include higher temperature resistance and a higher modulus of elasticity.

COPOLYMER FOAMS

Outstanding among the copolymer resins are the styrene-polyester copolymers which may be converted into cellular form without the use of pressure. The standard method for producing cellular board is to catalyze the resin, mix in the blowing agent, and expand in a mold consisting of two sheets of plate glass separated a suitable distance by the proper thickness of Koroseal gasket about the periphery. In order to make the resin "climb," it is essential that the entire interior surface of the mold be wet with the resin before placing the mold in an oven for the cure and blowing. Formerly styrene-polyester-copolymer cellular boards were quite brittle. However, the use of new internal plasticizers, which are copolymerized simultaneously, now makes it possible to obtain any degree of rigidity from brittle to rubbery.

PHYSICAL PROPERTIES OF CELLULAR MATERIALS

It should be emphasized that most of the cellular plastics are still only laboratory pilot-plant operations and a need exists for standardization of the products and reliable engineering data to facilitate their application to the airplane and to industry in general. Some of the physical properties of cellular plastic materials available from the literature, supplemented by various laboratory tests, are presented in Table 2. Where a range of density is indicated, the data given apply only to the lowest density. As can be seen, all of the plastics listed compare in specific gravity to balsa wood. As a matter of fact, cellular plastics have been given considerable developmental attention largely because of the shortage of balsa wood during the early part of the war.

Since balsa wood weighs from 8 to 15 lb per cu ft, it can be seen that cellular polystyrene or urea formaldehyde, both of which have been prepared in $1\frac{1}{2}$ lb per cu ft density, far surpass the natural material on a straight density basis. It is notable that when cellular cellulose acetate is expanded in a compression mold, the cells can be made to lie parallel to the movement of the plunger, thus simulating directional grain as found in balsa wood. Some samples tested had as much as 4 times the ultimate compressive strength with the grain as across the grain in cellular cellulose acetate. Hence the need for binding specifications can be seen.

APPLICATION OF CELLULAR BOARDS TO SANDWICH CONSTRUCTION

Cellular boards of the various plastics can be attached adhesively to high-strength skins on either face, forming structural or load-carrying sandwiches. It might be pointed out that the entire fuselage of the "Mosquito" bomber consisted of such a sandwich, i.e., a balsa-wood core separating aircraft spruce skins. Among the various adhesives used to bond skins to core, the furane resins are outstanding. Within the furane family are found cements which will adhere to metal, wood, and nearly every type of cellular plastic. Bonds can be obtained at low bonding pressure, lead-shot bags being frequently used in laboratory work. Special accelerators make it possible to cure the thermosetting cement without the application of heat. The styrene-polyester-copolymer resins, and Nylon 6 and 8 have likewise been found of value in bonding structural sandwiches.

In addition to forming a structure which is excellent in compression-loading, sandwiches containing synthetic cellular cores are light in weight and possess excellent heat- and

TABLE 3 PHYSICAL TEST DATA ON SANDWICH STRUCTURES

Specimen no.	g 1 in. width $g = \frac{t^2}{c}$	p Load per in. 18-in. span $p = \frac{43P}{L}$	Faces specification	Core specification	Total thickness inches	Weight lb per sq ft	Modulus of rupture
1	0.0516	155	20 Layers phenolic-impregnated paper	7/16-in. 7-ply basswood plywood	0.556	1.71	13500
2	0.0416	98	None	1/2-in. 5-ply Douglas fir plywood	0.500	1.50	10600
3	0.0416	67	Basswood XB&C	1/2-in. 7-ply spruce plywood	0.500	1.27	7250
4	0.0450	102	0.96 lb per sq ft ¼-in. Basswood, 12 layers either side	1/2-in. 7-ply basswood plywood	0.520	1.48	10200
5	0.0368	160	17 Layers paper[a]	Basswood[b] lumber core	0.470	1.53	19600
6	0.0323	124	15 Layers paper[a]	3/8-in. 5-ply basswood plywood	0.440	1.39	17300
7	0.0241	78	12 Layers paper[a]	5/16-in. 5-ply basswood plywood	0.380	1.30	14500
8	0.0150	72	10 Layers paper[a]	1/4-in. 5-ply birch plywood	0.300	1.38	21700
9	0.0104	55	17 Layers paper[a]	Basswood[b] lumber core	0.250	1.00	23600
10	0.0113	25	None	1/4-in. 5-ply basswood plywood	0.260	0.63	10000
11	0.0071	22	2 Layers paper[a]	3/16-in. 3-ply basswood plywood	0.207	0.80	13700
12	0.0787	30.3	3/32-in. 3-ply spruce both faces	1/2-in. thick cellular polystrene 4 lb per cu ft	0.687	0.90	13732
13	0.2760	35.1	3/32-in. 3-ply spruce both faces	1-in. thick cellular polystrene 4 lb per cu ft	1.287	1.07	8116
14	0.0785	40.2	3/32-in. 3-ply spruce both faces	1/2-in. thick Buna "S" cellular board 5 lb per cu ft	0.687	0.96	36560
15	0.2760	45.9	3/32-in. 3-ply spruce both faces	1-in. thick Buna "S" cellular board 5 lb per cu ft	1.287	1.17	9030

[a] CWPP phenol-formaldehyde low-pressure laminating varnish.
[b] Standard 1/2-in. Conso weld.

sound-insulating qualities. Since a cellular core supports the skins at all points over the surface area, a sandwich-type structure when used in airplane partitions, tables, etc., gives the feeling of being substantial, which is so frequently lacking in thin-gage metal-stiffener-type wall structures. The physical and structural properties of cellular polystyrene and butadiene-styrene sandwiches are related to numerous comparable wood-cored sandwich structures in Table 3.

CONCLUSIONS

Every class of synthetic-resin polymer has been converted into cellular form. Most of the cellular boards are available only from pilot-plant operations at present. Plastic cellular boards possess very low specific gravity and excellent heat- and sound-insulating qualities, in addition to having physical properties comparable to balsa wood. The chemical properties and uniformity obtainable should enable this form of plastic material to be used to good advantage in many airplane structural applications. The possibility of utilizing cellular boards as core material for structural sandwich construction should result in the saving of weight and in fabrication simplicity.

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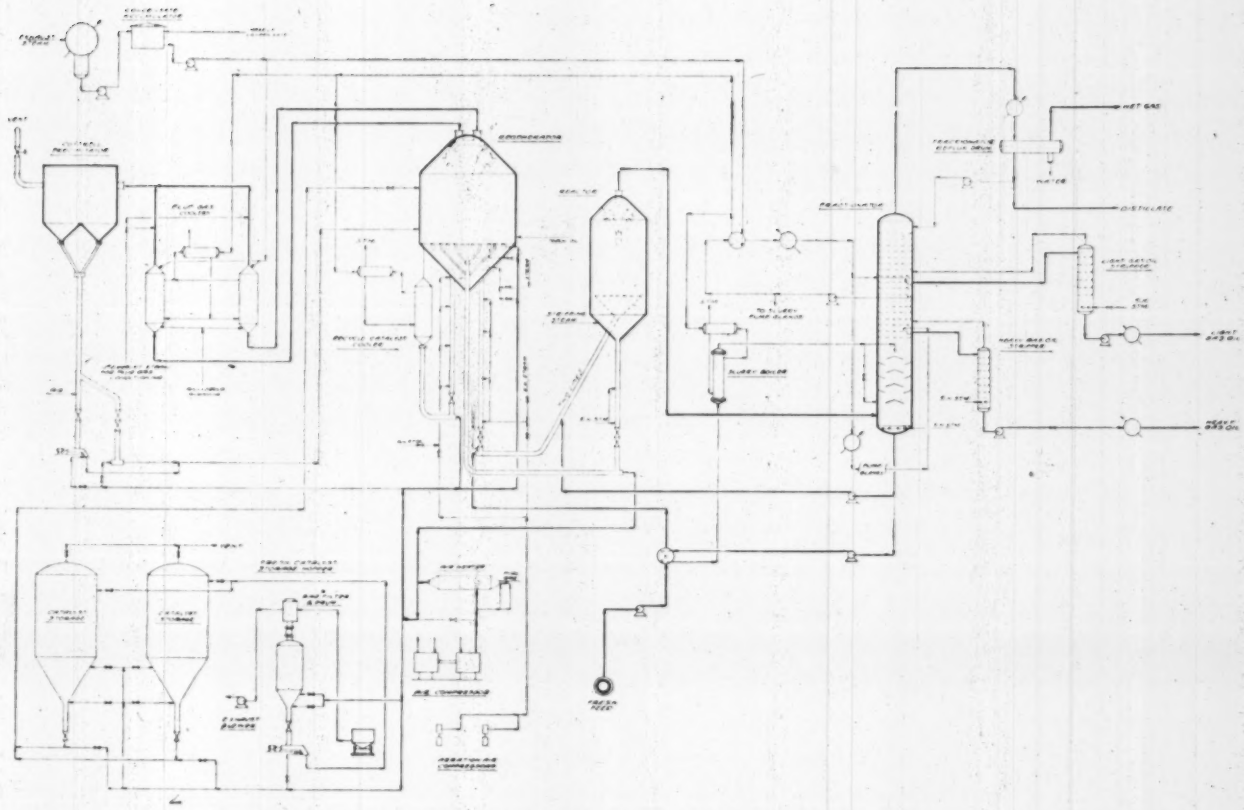

FIG. 1 FLOW SHEET OF FLUID CATALYST CRACKING UNIT

The MECHANISM *of* FLOW *in* FLUID CATALYST CRACKING

As Used in Refining High Octane Gasoline

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THE subject of catalytic cracking is one of tremendous interest to most engineers. The cracking operation itself is amazingly simple, and yet great numbers of trained technologists have concentrated their efforts on every detail to insure the satisfactory performance of the many cracking units installed. While the development of this process has been extremely rapid during the war period, security restrictions have prevented publication of the details of the operation until very recently.

Prior to the outbreak of the war catalytic cracking operations were limited to a number of fixed-bed units and pilot plants of more recent designs. No commercial fluid catalyst cracking units were in operation. At this stage of the development the primary interest in catalytic cracking was the production of fuel which would provide a high antiknock rating without the use of uneconomically large quantities of tetraethyl lead. When war was declared, the demand for aviation gasoline of high quality increased tremendously and production facilities involving catalytic cracking, alkylation, and associated refinery operations were rapidly expanded by the installation of units at strategic locations about the country. Of the catalytic cracking capacity installed in this expansion program for conversion of gas oil to products required by the war effort, about two thirds was of the fluid type.

Contributed by the Petroleum Committee of the Process Industries Division and presented at a meeting of the Metropolitan Section, New York, N. Y., May 10, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

FLUID CATALYST OPERATIONS

It is hardly necessary to point out to the engineering reader that catalytic operations are becoming more important every

day in promoting chemical reactions. In fluid catalyst operations the catalyst is used in the form of a coarse powder. When agitated or mixed with an aerating gas, the catalyst takes on the properties of a fluid in which condition it will flow freely from point to point as required by the process. Aside from the ease of handling powdered catalysts, much of the difficulty of catalyst manufacture is eliminated, and almost any catalytic material can easily be prepared for the fluid type of operation. As catalytic operations are extended and applied to new processes, the inherent adaptability of the fluid-type operation should make it a leader in the field.

The catalyst employed in fluid catalyst cracking is composed of an activated silica-alumina mixture which has an average particle diameter of about 50 microns, with small amounts of material less than 10 microns. It is not essential to satisfactory operation that a rigid size specification be followed, and commercial plants have operated satisfactorily with a 0–20 micron fraction of 0 to 40 per cent. It is also significant that variations in density, roughness, and hardness are allowable; although it would not be desirable to employ a fragile material which would continually break down to smaller particles.

THE CRACKING OPERATION

In the cracking operation which is shown on the flow sheet, Fig. 1, oil and catalyst enter the reactor in which cracking proceeds. The catalyst settles from the products of reaction forming a fluid bed maintained in this condition by the upward flow of the entering vapors. As a result of the cracking reactions, coke is deposited upon the catalyst. The spent catalyst, carrying the coke deposit, flows downward through a steam-stripping section, thence through the spent catalyst standpipe, and is released through the slide valve into the carrier line, where it is dispersed with air and carried into the regenerator. By contact with air in the regeneration system the coke deposit is burned from the catalyst.

A bed of regenerated catalyst is formed in the regenerator similar to the bed which exists in the reactor, except that in this case fluidity is maintained by the flow of air and flue gas passing through the bed. Regenerated catalyst from which coke has been removed is withdrawn from the bed and flows downward through the regenerated catalyst standpipe to the point where it is mixed with the oil stream being fed to the reactor. Flue gas leaving the regenerator and carrying a small amount of entrained catalyst passes through a set of cyclone separators which recover a large proportion of the entrained material, following which operation final recovery is effected in an electrical precipitator.

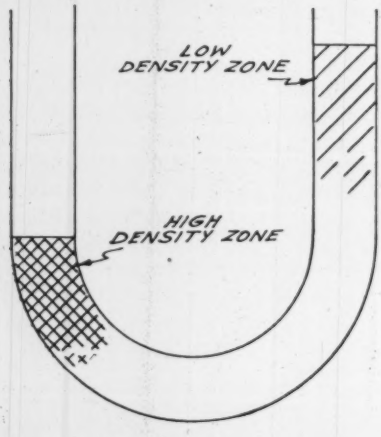

FIG. 2

The oil vapors leaving the reaction zone are similarly passed through a set of cyclones for partial catalyst recovery and are subsequently scrubbed with oil in the base of the fractionator tower for final clean up of catalyst. Oil from the base of the fractionator tower is returned to the reaction zone to prevent loss of catalyst. The upper section of the fractionator tower is used to separate products of reaction according to boiling range, and it is general practice to withdraw a heavy gas-oil stream, a heating-oil stream, and a liquid-distillate product. Some condensable gas is formed in the reaction which is processed in subsequent recovery equipment.

The reaction is carried out at temperatures in the order of 900 to 1000 F, and the regeneration operation is carried out at still higher temperatures, around 1100 F. As a result of this temperature difference it is apparent that the circulation of catalyst serves also as a means of transferring heat from the regenerator to the reaction system, and this transfer may be so extensive as to permit charging cold liquid oil to the reactor inlet, while maintaining the desired temperature in the reaction zone.

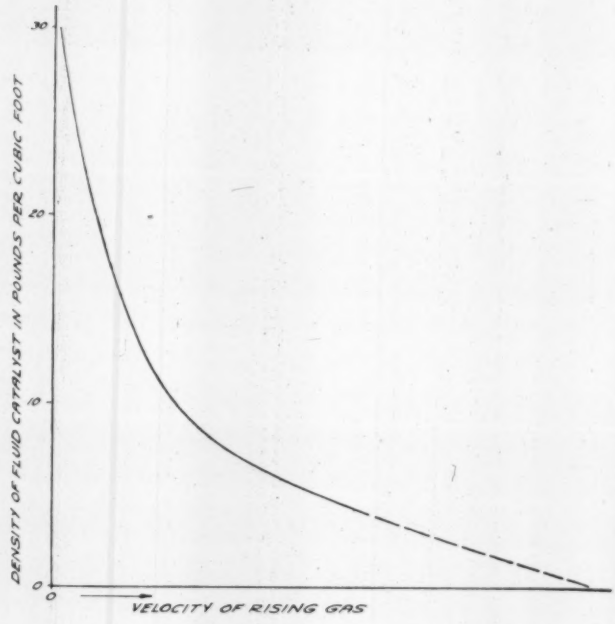

FIG. 3

ENGINEERING PROBLEMS INVOLVED IN PROCESS

Although the cracking operation is extremely simple, several complications are present in engineering considerations of the design of the equipment employed. The vessels and piping must be able to withstand the operating temperatures. Metal expansion must be given careful consideration in the design and arrangement of the standpipes and carrier lines provided for the circulation of catalyst. The operating temperatures are in the maximum range where carbon steel has been found practical, and in some units chrome-moly alloys have been considered advisable. It is general practice to design on the basis of creep strength at these elevated temperatures. It is also general practice to protect the regenerator itself from the high operating temperatures with an internal liner of insulating material, and in some cases internal insulation has been used in the lines of the regeneration system.

As previously pointed out, the circulating catalyst performs numerous functions in the operation. Besides promoting the desired reaction, it serves as a means of transferring heat to the reaction zone and removing coke produced in the reaction from

this zone. The quantity of catalyst must be under close control so as to maintain the desired reaction conditions. In designing this type of unit it is apparent that pressure drop through the carrier lines and pressure build-up in the standpipes is of great importance. In simple terms, each circuit for the transfer of catalyst may be likened to a U-tube in which the density on one side is maintained at a sufficient value to offset the pressure drop against the desired flow on the other side.

Referring to Fig. 2 it will be seen that in a static system where a column of dense fluid catalyst is maintained on one side of a U-tube it would maintain itself in equilibrium with a higher column of less dense material on the other side. By comparing two columns of equal height it is apparent that a higher pressure build-up would be obtained in the denser column. The standpipe of an operating unit contains a dense column, whereas the carrier line operates at low density. Actually the standpipes are designed to give more than the required pressure build-up so that the slide valve at the base of the standpipe may be used as the final point of control.

Density and fluidity control in the standpipes is provided by the admission of small amounts of aeration gas at various points. By increasing the amount of aeration gas admitted, the standpipe density may be reduced over a limited range. Once flow has been established in the standpipe, aeration gas is no longer necessary to maintain fluidity since sufficient agitation is provided as a result of flow.

The transfer of catalyst in the carrier lines is effected by velocities in the order of 30 feet per second. Carrier-line densities are, of course, much lower than those of the standpipes since the quantity of vapor handled is very large. The pressure drop, or resistance to flow, in the carrier line is a function of the catalyst density and the velocity at which the catalyst is carried.

The manner in which density may be controlled in a fluid system is illustrated in Fig. 3. It will be noted that as a mass of powdered material is agitated with increasing amounts of vapor flowing through the mass, lower and lower densities result. Thus, a standpipe would represent operation at the higher range of densities while carrier lines function at low densities with large vapor volumes. The absolute densities in any fluid system are also affected by the characteristics of the catalyst employed, and in general, if particle size and particle density are increased the operating density will increase at a given vapor velocity.

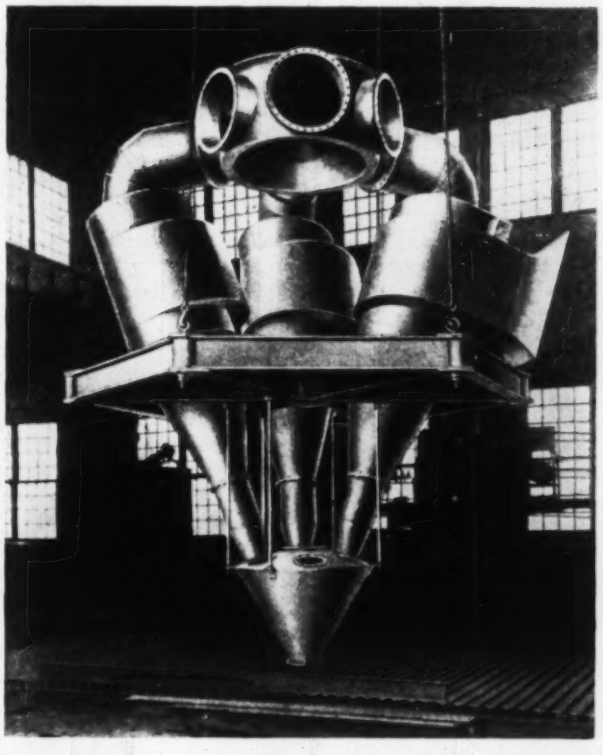

FIG. 4 ARRANGEMENT OF CYCLONE SEPARATORS

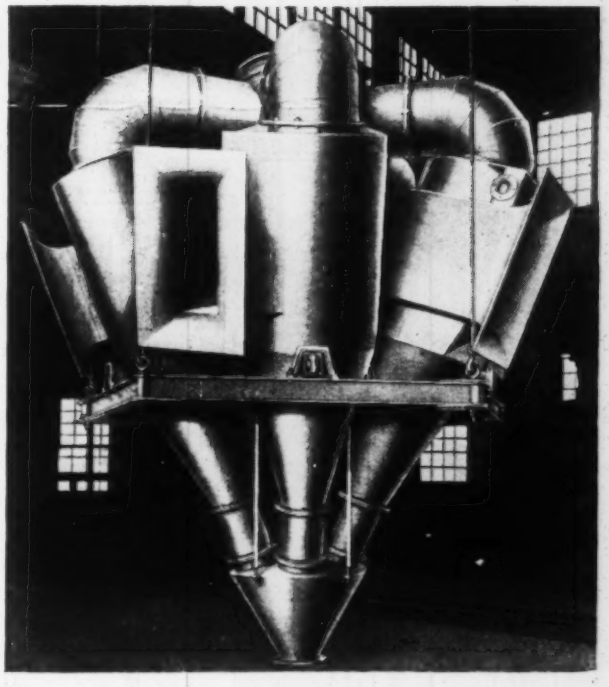

FIG. 5 CYCLONE ASSEMBLY

Experience has indicated that it is necessary to take certain precautions against undue erosion of the catalyst piping by the circulating catalyst. This tendency toward erosion has been found to be a function of catalyst density and the velocity of the carrying medium. By maintaining velocities and densities in the proper order, erosion may be practically eliminated, as witnessed by the fact that the first catalytic cracking unit to be put into operation in the Lake Charles refinery of Cities Service Oil Company was in continuous operation on its first run on synthetic catalyst for a period of 300 days. The second and third units completed runs of 333 and 287 days, respectively, and all three units were shut down voluntarily and not by the need of repair work on the equipment. The carrier lines terminate in the larger vessels and after distribution of the entering catalyst, a fluidized bed is formed in the vessel. The density of the bed again depends upon the velocity of the rising vapors; and at higher velocities lower densities will be found.

RECOVERING CATALYST FROM VAPOR

The vapors leaving the catalyst bed carry a small amount of entrained catalyst, a large portion of which is recovered by cyclone separating equipment, Figs. 4 and 5. Assemblies similar to the one shown are located in the upper heads of the reaction and regeneration vessels. The cyclones deliver catalyst at the apex of the conical section to a small standpipe, generally designated as the dip-leg, in which a head of dense catalyst is built up so that the recovered material may be returned to the bed. As stated previously, the flue gases leaving the regener-

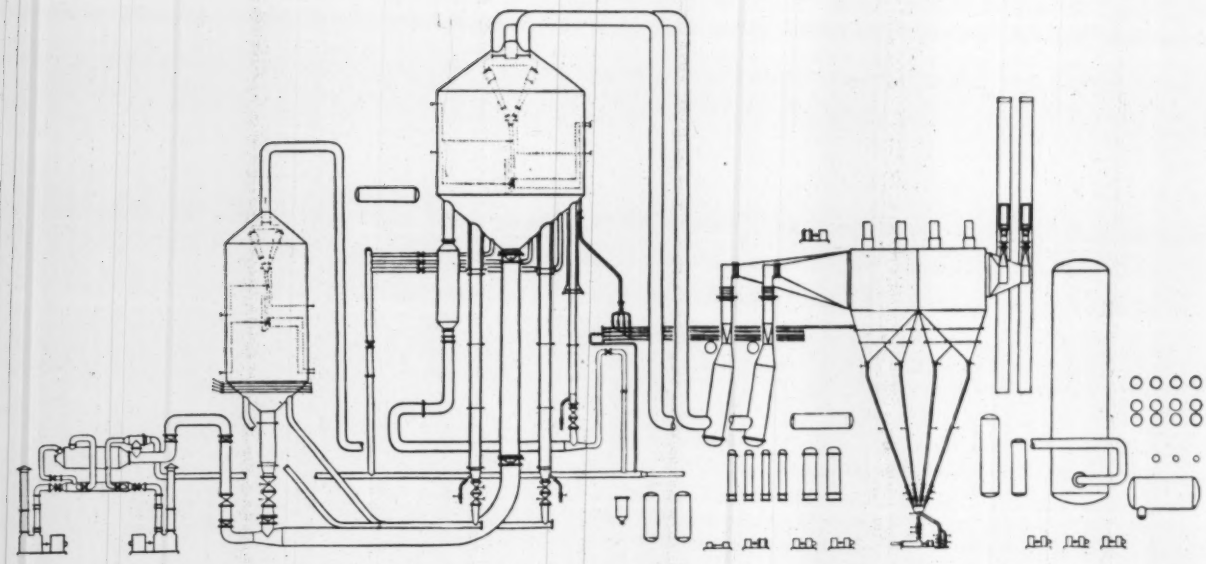

FIG. 6 ELEVATION SKETCH OF UNIT

ator cyclones flow through a Cottrell precipitator for final recovery of the catalyst. The combined actions of the electrical and cyclone recovery equipment are sufficient to maintain the particle distribution of the circulating catalyst almost identical with that of the catalyst charged to the unit.

EQUIPMENT DESIGN

To present a more concrete picture of the entire unit, Fig. 6 shows the physical arrangement of a typical plant with special emphasis on heights. The regenerator which is about 40 ft diam is supported about 120 ft above grade with the reactor somewhat lower at about 60 ft. Here may be seen the rotation and expansion joints required in the main carrier system. The spent-catalyst carrier line is 6 ft diam, and the standpipe feeding catalyst from the reactor is 5 ft in size. The highest steelwork in the structure is nearly 200 ft above ground level, but it must be remembered that the tremendous size of the equipment required by a plant of this capacity is a pertinent factor in the over-all height. The top and bottom cones of the regenerator take up about 40 ft and the tops of the slide valves are of necessity about 20 ft above grade. Smaller units naturally employ smaller vessels and piping and therefore require considerably less vertical height.

Fig. 7 shows the complete cracking plant for which Fig. 6 is the elevation sketch. Actually, two units were installed in this refinery as a part of the company's contribution to the war effort in the manufacture of aviation gasoline.

While this paper has covered some of the general aspects of flow in fluid catalyst cracking, it must be remembered that the flow of catalyst is intimately related to the process involved. For this reason the more technical problems connected with the flow of catalyst can only be approached with a thorough understanding of the process being considered and complete knowledge of the characteristics of the catalyst to be employed.

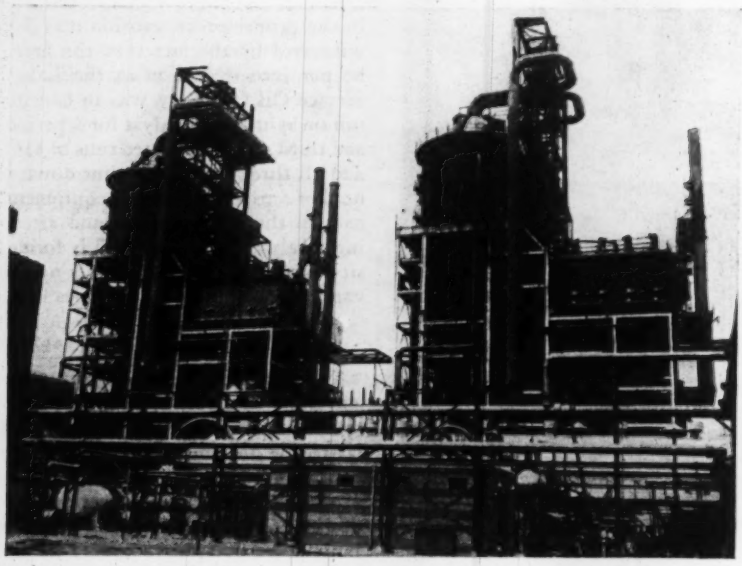

FIG. 7 PHOTOGRAPH OF TWO LARGE CATALYTIC CRACKING UNITS

Less TALK, *More* ACTION, *Needed on* PROFESSIONAL STANDING

By GREGORY M. DEXTER

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WHY not do something about it? Such a question should be in the mind of every engineer who has read the numerous articles in MECHANICAL ENGINEERING on the need for participation by engineers in public affairs. A few quotations from recent issues will lend point to the question:

Robert M. Gates, Past-President of the Society, has argued practically that the engineering profession "faces greater, broader responsibilities than ever in the making of the world of tomorrow." He has quoted with approval Auguste Comte's statement that a man wrapped up in detail shows "a miserable indifference about the general course of human affairs as long as there are equations to resolve or pins to manufacture" (1).[1]

R. E. Gillmor, former president of the Sperry Gyroscope Company, emphasized the necessity for the Christian attitude when he said, "The welfare of all of us is inextricably linked together; for selfish as well as for altruistic reasons, each of us must accept the responsibility of being our brother's keeper. The creative minds carry an especially heavy responsibility for on them depends our rate of progress toward a better world. Let us find better ways of recognizing and encouraging them so that they can do more to help us" (2).

Everett S. Lee, as chairman of the E.C.P.D., agrees with the foregoing for he has quoted with approval from the "Faith of the Engineer" that engineers should have the "consciousness, always, that our special expertness carries with it the obligation to serve humanity with complete sincerity" (3).

Roy V. Wright, Past-President of the Society, advanced the argument of self-interest for engineers in promoting public welfare when he said: "Moreover, their prestige and status in the community will be further enhanced to the extent to which they participate constructively in community and public affairs" (4).

A. A. Potter, Past-President of the Society, has used research as his stepping stone to public welfare: "For new wealth to replace the material losses the world has suffered in this war we must create new wealth through research and invention" (5).

A. R. Stevenson, Jr., and K. B. McEachron, Jr., in discussing education, reach Mr. Potter's conclusion as to the necessity for new wealth: "Therefore, we must have ingenuity and inventiveness to think up new things which people will want to buy. Without good engineers, new successful enterprises are not possible. It takes engineers to invent, design, develop, and put new products into production" (7).

Many engineering ideas, however, by reason of various selfish motives do not get beyond the stage of a report or drawing filed for future reference. Yet research or design that is not published is largely wasted. Too many people forget that an economic study of engineering design, involved in a proposed project for betterment, frequently involves as high a degree of inventiveness as the preliminary work in the laboratory or on the drafting board. Whenever such a study is suppressed, civilization suffers. If engineers are to make more rapid progress in influencing public affairs, they must find some way of getting the economics of their engineering ideas before the public.

Morris L. Cooke, consulting engineer, senses the problem just mentioned for he has said we have got "to think out methods for breaking down the barriers which separate science and engineering from the whole life of the community . . . . . for only thus can science through politics become dominant in the affairs of mankind" (8).

W. E. Wickenden, president of the Case School of Applied Science, is as impatient as some others at the barrier between engineers and the "general course of human affairs" for he has said, "This is no time for engineers to wrap themselves in the mantle of isolation; let us get together and be about our common business" (9).

Robert E. Doherty, president of the Carnegie Institute of Technology, is not afraid of any political issues involved in promoting public welfare for he would have engineers "serve their country by expert counsel in their field by participating as civic leaders in community enterprises, and by forming intelligent judgments on political issues and actively supporting them." (6).

D. Robert Yarnall, now President of the Society, argued that the social responsibility of engineers involves freedom for ideas when he said (17):

"Somewhere along the line with the help of good environment and sound training there must be built in us a sense of concern, a social conscience, that will not be satisfied with personal success within the bounds of our profession—but will drive us on and out *with other citizens:*

"(*a*) To carry our share of the burdens of world sufferings.

"(*b*) To assume our constructive part in responsibility for good wholesome government.

"(*c*) To help in making secure those precious freedoms, among them the right without fear to write our Letter to the Editor."

Additional quotations similar to the foregoing from MECHANICAL ENGINEERING could be given without difficulty. They are, however, not much better than platitudes, the smooth phrases we applaud and about which we do nothing, unless implemented by action. The direction that such action could take has been suggested in the "Proposed Canons of Ethics for E.C.P.D." (10). Two quotations therefrom as to the engineer are pat:

"He will assist public officials and others in attaining a fair and correct general understanding of engineering matters, extend the public knowledge of engineering, and discourage untrue, unfair, and exaggerated statements regarding engineering.

"He will recognize the fact that meetings of engineering societies and the engineering press provide the proper forum for technical discussions and criticisms, and also that clear statements of facts relating to engineering enterprises are often of value to the public when they are prepared for laymen's under-

[1] Numbers in parentheses refer to the Bibliography at end of paper.

standing and released by competent authority through the public press."

PUBLICITY FOR ENGINEERS' IDEAS

The trouble with this suggested approach is that engineers find it hard to get a public hearing except on such relative trivia as "equations to resolve or pins to manufacture." On such subjects, the professional societies and engineering press offer reasonable opportunities for publicity. When the engineer, however, tries to apply the significance of the resolution of his equations and methods of manufacturing pins to public affairs, he runs into a censorship that can be surmounted only with difficulty. Even in world affairs his advice is not wanted.

Scientists alarmed over the possibilities of the atomic bomb have argued for a world organization. The *New York Times* of Nov. 8, 1945, in comment thereon, carried the following statement: "It was interesting that both Mr. Churchill and Mr. Bevin sharply attacked the scientists who by their alarmist statements have, in Mr. Bevin's words, been trying to 'supersede the state.' "

In less world-shattering problems the engineer's discussion of public welfare also is not wanted. Some examples are as follows:

Chemist "A" wrote a detailed discussion, based on considerable research, of the technical aspects and benefits to society of adding liquid "Z" to liquid "Y" to make a mixture that would open a new market for farm products. He considered such market better for the farmer than subsidies for hogs killed and corn plowed under. One professional society refused publication of his paper on the plea that it was not technically interesting. It has been published as part of a bulletin of a state college. Claims made therein, however, have gone to the public without such criticism as would have been possible in a professional meeting. Chemist "A" was denied an opportunity to take part in public affairs and the professional society failed to meet its responsibility for service to the public by not affording opportunity for technical discussion of his paper.

An engineer presented a paper on a case study, without names, of electrical service by a public utility in a suburban community where the sale of both manufactured gas and electricity was involved. His professional society asked him to rewrite the paper and use names. Considerable time was used up in argument for permission to present the paper. Then when publication was refused on the ground that the paper was not technically interesting, a committee of the society said that such papers were acceptable for publication only if presented as case studies without names.

The preceding decision as to use of case studies for economic engineering discussions does not solve the problem of participation by engineers in public affairs. A case study is innocuous. The public is not going to pay any attention to the recommendations of engineers unless they are specific to existing problems. A few examples will show how inadequate is the proposed solution:

INADEQUACIES OF CASE STUDIES

Railroad "B" has electrified suburban service for several hundred thousand people living outside a city of several million. The passenger cars used are heavy, acceleration and deceleration are slow, frequency of service is poor, and intensity of artificial illumination is low. The railroad is presumably desirous of continuing to use such obsolete equipment as long as possible. The Public Service Commission in the lack of public demand has taken no action to force improved service and has the reputation of being ineffective in its work. An engineering study of what would be possible on this railroad with lightweight, high-speed, electric equipment provided with comfortable seats and adequate artificial illumination should be of great interest to the communities affected if accompanied by estimates of capital and operating costs. Neither the railroad nor the Public Service Commission can be expected to present such an engineering study to the public. The communities affected do not appreciate what is possible until it is published. And no professional paper on this problem is possible before an engineering society so long as it has to be presented as a case study. The study once made, of course, would have application to similar problems elsewhere. Cost figures would become public property that now are buried in the files of railroads and car-manufacturing companies. A railroad, finally, is a semi-public corporation whose operations should be open to public discussion.

Chemical company "C" has a practical monopoly of a product "W" that sells at a relatively high price. The sales are small compared with much cheaper products such as soda ash. "C" is said to have paid about $25,000,000 for the plant where "W" is now made and obviously is not interested in developing a new method for making it that would scrap that investment unless earnings are enough to charge off the loss in investment in about three years. Yet a new method for making "W" is available that careful study has shown to be technically sound. Development expenses would be high, possibly $500,000 or so. Any chemical company that tried to develop the new process for making "W" faces the probability that in selling or buying some chemical it would need the co-operation of "C." "C" obviously by some arbitrariness can do much to hinder the development of the new process. Yet it involves the application of a proved method in mechanical engineering that has not been exploited to any great extent. The sale of "W" at about 20 per cent of its present price is probably possible if the new plant were located where cheap fuel is available. Large amounts of by-product power at low cost would also be developed. The great reduction in selling price of "W" should open large new markets that cannot now be envisaged. Other new products would be developed by using "W." There is, however, no possibility of discussing this new process as a case study. Yet such discussion would be an inestimable service to society.

Dr. Irving Langmuir, Nobel Prize winner as physical chemist and associate director of research for the General Electric Company, in testifying before the Special Senate Committee on the atomic bomb (*The New York Times*, Dec. 1, 1945), said Russia was building a large experimental plant costing about $100,000,000 to operate a blast furnace with oxygen instead of air. He said Russia had plans to use oxygen on all its blast furnaces at a cost of about $2,000,000,000.

Let us assume for the sake of this argument that a blast furnace so operated produces better steel at lower cost than the air-operated blast furnaces in the United States. Would The American Society of Mechanical Engineers encourage one of its members to present before it a professional paper on the economic comparison in capital and operating costs between the two types of blast furnaces and on the qualities of steel produced? Would not the Society's representatives argue that the new process was not proved, that such a paper was suggesting the obsolescence of the United States steel industry, and that it could not be published because of implications that might not be true even if demonstrated in Russia? To what extent would Society representatives resist any pressure by large steel companies against the presentation and publication of such a report?

The foregoing questions are not so foolish as the thoughtless may assume. Note the comments of Robert Morse Lovett on "Freedom in the Fine Arts:" (16)

"It may be contended that the proper way to free any art from the interference of unqualified and improperly interested

persons is for the practitioners of it to organize as a guild and set up their own censorship responsible to the public as well as to themselves. . . . A moment's reflection will convince anyone that censorship by artists is the worst sort of censorship of art. Such internal control exercises a far more depressing restriction upon the arts than the most rigid external censorship. . . . There have been musical guilds, and their adverse influence is depicted in 'Die Meistersinger' and 'Feuersnot.' If these guilds had prevailed we should have had no Wagner, no Strauss, no Schoenberg, no Stravinsky. There have been salons of painting and sculpture. . . . if the salons had prevailed we should have had no Pre-Raphaelites, no Impressionists, no Postimpressionists, no Monet, no Cézanne, no Matisse, no Gauguin."

A lesson for engineers on freedom for the economics involved in engineering ideas will be found in a brief review of conditions in newspaper publishing.

The claim is repeatedly made by the press that it has served the public faithfully and well. Considerable evidence of such service, relatively free from censorship, does exist as to some newspapers but even the best of them have had their blind spots. A veteran newspaper man, Oswald Garrison Villard, in his discussion of the successes and failures of the press has sensed the problem that faces not only it but the engineering profession. He says: (26)

"The battle for democracy will not have been won when Germany is beaten. The war itself will produce new dangers to it, both here and abroad. . . . All the more necessary is it, therefore, to focus popular attention upon the fundamental problems of the transmission of factual and correct news, free from selfish business or governmental control, to the peoples of the earth. For without such unbiased information, the roads to dictatorship lie open."

William Allen White, a revered newspaperman, has criticized the press as being so tied up to the viewpoint of big business as not to meet the needs of the general public (13). A somewhat lurid account of such failure is given by George Seldes (11, 12). Susan M. Kingsbury has attempted to make an objective analysis of the press with results showing that considerable bias and distortion of news exists (15). A very readable account of human successes and failures in the work of the press is that of Kenneth Stewart, a working newspaperman (14). But they all show that the press on the whole is not getting correct news to the "peoples of the earth." That failure is the engineer's opportunity.

ENGINEERING ECONOMICS SHOULD BE FREELY DISCUSSED

The engineer, however, has little chance of showing the economic impact of new developments in applied science upon existing corporate and governmental institutions and methods if he cannot first of all get a hearing before a professional engineering association. That hearing to be of value to society must be in the form of a nontechnically written report of advantages and disadvantages of a proposed engineering development and should be accompanied with estimated capital and operating costs in comparison with existing costs. Professional papers of that sort are well-nigh unknown before engineering associations. Engineers, therefore, are certainly faced with the problem of getting factual and correct economic news of engineering developments to the "peoples of the earth."

A still further lesson for engineers on the necessity for freedom for engineering ideas involving economic discussions will be found in the churches. In the words of Dr. Bernard Iddings Bell, "The Christian Church has today for the most part ceased to have any influence worth mentioning over human affairs, particularly on men who think and lead." No one cause can be set for this condition, but again, in the words of Dr. Bell, "The really alarming weakness, however, lies not in the voices of great churchmen saying occasionally superficial things, for there are, as has been seen, plenty of leaders whose utterances are not superficial, but rather in lack of interest in the moral revival among the rank and file of the Church's membership and in the timidity of most of its leaders, even those who understand, in presenting issues bluntly and in plain language to the people" (18).

Additional support for this thought will be found in such books as Andrew R. Osborn (19) and Walter Russell Bowie (20) have written.

The comments of Dr. Bell on the churches could be made with equal applicability to The American Society of Mechanical Engineers. We have the universal complaint as to the lack of influence of engineers in public affairs. We have prominent leaders of the Society asking for more active interest in public welfare just as some great churchmen are speaking out for correction of social wrongs. We have the rank and file of the Society membership apparently without interest in public welfare. And, finally, we have the timidity of most of the Society's leaders in presenting the issues involved in public welfare "bluntly and in plain language."

FREEDOM OF EXPRESSION HAMPERED IN MANY WAYS

The Society has a membership of about 20,000 of which only about 700 are consultants of whom independence of opinion is expected. The majority of the remaining 19,000 members are presumably largely employed by industry. Independence of opinion cannot be expected of them, particularly where the economics involved in any professional paper run counter to the interests of their employers. That portion of the membership in government employ is by the nature thereof usually barred from comment on an engineering development if it impinges on private business. The Society of necessity by the nature of its membership must be vigilant if public welfare is to be advanced.

Nor is the solution of engineering participation in public welfare to be found in our state universities, Federal laboratories, and state control of science.

Freedom of expression, particularly where economic conflicts are involved, is not generally available in our state universities. Numerous examples of restrictions on such freedom could be given. One will suffice, namely, the attempt to restrict publication of the findings by Iowa State College on the desirability of oleomargarine in economic competition with butter. Reference may be made to Wesley McCune (21), to J. M. O'Neill (22, 23) as chairman of the Committee on Academic Freedom of the American Civil Liberties Union, and to Prof. R. E. Buchanan (23) as director of the Agricultural Experiment Station of Iowa State College.

Conditions as to freedom of expression are no better in the four Federal laboratories on which the U. S. Government has spent several millions of dollars alone for buildings and equipment. Such laboratories have to depend for their appropriations on representatives and senators whose interest in any particular research project is limited by the selfish desires of the state they represent. We thus have the spectacle of research on chemicals from starch in corn being pushed aggressively in one laboratory although nothing much has been done in another laboratory on similar research for chemicals from starch in sweet potatoes. The latter starch per pound delivered at the factory should be much cheaper than the starch in corn. The states growing corn, however, have much stronger political representation in Congress than the extreme southern states where sweet potatoes as a source of cheap chemicals are an economic possibility. Similar political limitations are certain to hamstring numerous other research projects where conflict with state or large corporation interests is involved. And cer-

tainly a Federal employee has little freedom to discuss the economic aspects of engineering developments as to their effect on selfish corporation interests.

STATE CONTROL OF RESEARCH

Mr. John R. Baker (24), as secretary for the British Society for Freedom in Science, has successfully controverted the idea that the central planning of the state can be relied upon to advance the frontiers of science. The demand for state control of research, however, has arisen because of the feeling on the part of many that scientists would thereby serve society more efficiently. If reform in scientific service is needed, it can be more successfully secured by permitting greater use of the platform and publications of professional associations for the discussion of various developments, including their economic impingement on existing corporate and governmental institutions and methods, and in such freer use, The American Society of Mechanical Engineers has an outstanding opportunity to serve society. Any censorship at all defeats the very purpose of research as Zechariah Chafee, Jr., has well said (25):

"The true meaning of freedom of speech seems to be this' One of the most important purposes of society and government is the discovery and spread of truth on subjects of general concern. This is possible only through absolutely unlimited discussion, for, as Bagehot points out, once force is thrown into the argument, it becomes a matter of chance whether it is thrown on the false side or the true, and truth loses all its natural advantage in the contest."

Public discussion, with capital and operating costs, of engineering developments involved in public welfare and cutting across the selfish interests of large corporations is not permitted before professional societies. Certainly such discussion is not possible as case studies. And engineers, therefore, are stymied if they desire to serve society altruistically with their special knowledge.

This plea, that professional societies afford engineers an opportunity to take part in public affairs by giving them a platform from which they can be heard and a publication where their opinions can be read, can best be concluded by quoting again from Robert M. Gates, Past-President of the Society, as follows:

"The heritage of freedom Americans enjoy, which has permitted our profession to make its finest achievements and which we depend on for future progress, cannot be taken for granted—else we shall lose it" (1).

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Gas-Turbine Plant

IT was recently disclosed that successful operation at a gas temperature of 1350 F has been accomplished in a series of successively increasing temperature tests on an Allis-Chalmers experimental gas turbine plant installed in the U. S. Naval Engineering Experiment Station at Annapolis, Md. Designed and built for eventual operation with hot gas at a temperature of 1500 F, the 3500 hp unit is the first large multistage gas turbine for continuous power generation at high efficiency ever operated successfully at such high temperature.

Although developed as a Navy project, its basic elements have characteristics suitable for both land and marine practice.

Numerous mechanical, metallurgical, and fluid flow problems so prominent in gas turbine development have already been overcome and much has been determined about operating characteristics of the turbine and compressor in completed stages of the comprehensive test program.

Designed for high efficiency the Annapolis unit embodies innovations in cooling methods permitting the multistage turbines to operate safely at high inlet temperature by avoiding the undue weakening effect of the high temperature on the materials used for the rotating parts.

The plant is arranged with two turbines operating in parallel—one turbine supplying the power required to drive the compressor, the second turbine furnishing the power necessary to satisfy the requirements of the driven machine or dynamometer. The compressor unit operates at a speed commensurate with the lowest possible fuel consumption. Fresh air enters the compressor at 40,000 cu ft per min and is discharged at a pressure of 45 lb per sq in. to the heat exchanger where it picks up heat from the turbine exhaust gases. The heated air then passes through two separately oil-fired combustion chambers where it is further heated to the desired turbine inlet temperatures. The gases then expand in two multistage turbines, one of which supplies the power to drive the compressor, the other furnishing external shaft power.

A Survey of

COLLECTIVE BARGAINING[1]

By CHARLES A. MYERS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

AT a time when strike news has been pushing everything else out of the top headlines, it is particularly important to take stock of the institution, "collective bargaining," which seems temporarily to have broken down in some of the country's larger industries. What has been the experience with collective bargaining in recent years? What conclusions are reached by those who have lived with it and studied it in various industries? Answers to these questions are found in a timely little book just published by The Twentieth Century Fund.[2] It deserves wide reading by business executives, labor leaders, and anyone seriously interested in going behind the headlines.

The book is in two parts: (1) A summary of recent experience in collective bargaining, written in very readable form and based largely on a more comprehensive study published in 1942 by The Twentieth Century Fund.[3] (2) A report and recommendations by The Twentieth Century Fund's Labor Committee, consisting of eight representatives of management, union labor, government, and the public.[4] The conclusions reached by this Committee are particularly significant.

BASIC FINDINGS

Four basic findings, which are drawn in part from the more detailed factual survey in the first part of the book, are central to the Committee's report: "(1) That collective bargaining, as an instrument of public and industrial policy, is here to stay; (2) that, like any other social invention, collective bargaining is subject to abuses that at times can be as vicious as its uses are generally valuable; (3) that efforts to deflect the aims and destroy the purposes of collective bargaining may foster social tensions of a kind that threaten the equilibrium of our economy; (4) that collective bargaining can be, and should increasingly become, a technique to help insure a larger and more regular output of goods and services, to maintain high levels of purchasing power, to establish clear lines of communication between employer and worker, to inspire and intensify their joint responsibility and responsiveness to their common interests, and the interests of the national community, and to promote that industrial self-government which, inside the plant, as within the community, is democracy's safeguard."

Pointing out that there is a body of mature experience in collective bargaining in only a few industries, such as printing, construction, the metal trades, men's and women's clothing, coal mining, railroads, and glass, the Committee emphasizes that "to apply collective bargaining competently, to use it even reasonably well, requires hard work—hard work for management and union alike; and, like most hard work, it is easier to evade than to carry out."

Once a collective agreement is signed, this work has just begun. "The Committee therefore suggests that the key to postwar industrial harmony is to be found in the intelligent, equitable, and patient administration of collective-bargaining contracts." More attention, rather than less, must be given to "procedures for joint discussion and review of such questions as: Alterations in the (wage) rates when operations are modified, or altogether transformed; job classification; the use of merit-rating and incentive systems; seniority, re-employment of veterans; devices to spread the work, adjustment in hours, and related issues."

ECONOMIC ASPECTS

In a section on "The Economics of Collective Bargaining," the Committee asserts that "a desire to get the controlling facts, to ascertain an accurate ratio between labor costs and company earnings, are characteristics of informed sophisticated bargainers. This whole approach presupposes a certain ripeness of judgment, a willingness to explore mutually, that as a rule go with maturity in the management-union relationship." The dangers of both management and union "pricing themselves and their product out of the market" are stressed, and the Committee recommends that "when management and union get together to make a bargain, they should keep in the front of their minds that their arrangements will influence the price of the product which must be sold a third party, the consumer," who may do his own bargaining later if he refuses to buy.

As a step toward greater realization by management and unions of the public interest in their bargains, the Committee recommends serious consideration of the advantages of market-wide collective bargaining, such as exists in coal mining, the clothing industry, and shipbuilding. If this were done, employers in many industries would have to combine into associations for negotiating with unions. Certainly, in industries where individual employers are confronted today with a strong national union, strengthening of the bargaining power of em-

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[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Trends in Collective Bargaining: A Summary of Recent Experience," by S. T. Williamson and Herbert Harris; and "Report and Recommendations," by the Labor Committee, The Twentieth Century Fund, New York, N. Y., 1945, 254 pp., $2.

[3] "How Collective Bargaining Works. A Survey of Experience in Leading American Industries" (under the research direction of Harry A. Millis), The Twentieth Century Fund, New York, N. Y., 1942, 965 pp., $4. This was reviewed by the present reviewer in MECHANICAL ENGINEERING, vol. 65, 1943, pp. 208–209.

[4] The membership of the Labor Committee is as follows: William H. Davis, chairman, formerly director, U. S. Office of Economic Stabilization, formerly chairman, National War Labor Board; William L. Chenery, publisher, *Collier's Weekly;* Howard Coonley, chairman of the board, Walworth Company, Inc.; formerly president, National Association of Manufacturers; Clinton S. Golden, assistant to the president, United Steelworkers of America, affiliated with the Congress of Industrial Organizations; Frazier MacIver, vice-president, Phoenix Hosiery Company; Sumner H. Slichter, Lamont University Professor, Harvard University; Robert J. Watt, International Representative, American Federation of Labor; Edwin E. Witte, professor of economics, University of Wisconsin, formerly public member, National War Labor Board.

The report of this Committee has been published separately and is available from the publishers for twenty-five cents.

ployers as a group is badly needed. If bargaining power is roughly equal on both sides, collective bargaining is likely to be more stable than where one side holds the whip hand. But there is always the danger, of which the Committee is not unaware, that powerfully organized groups of employers and labor in an industry or in a local market will feather their own nests at the expense of consumers. This danger is particularly great when the demand for the product or service is relatively inelastic, as is the case when no substitutes are readily available.

The Committee believes that "emphasis upon market-wide collective bargaining would inevitably foster the wider use of technical assistants. . . . It is apparent that, in view of the delicate interrelatedness of our economy, fact finding and fact interpretation must be the handmaidens of a market analysis more detailed, scientific, and exhaustive than ever before. Both managements and unions need definite data superior to that which they now possess. Moreover, they must be prepared to disclose all pertinent information at their disposal. The United States community cannot permit collective bargaining to be merely a game of blindman's buff . . ."

GOVERNMENT INTERVENTION

In a section on "The Politics of Collective Bargaining," the Committee urges that government intervention in the details of the union-management relationship, necessary during wartime, be reduced to a minimum. War Labor Board experience with tripartite dispute panels is the basis for the recommendation that "voluntary mediation boards, composed equally of management, labor, and public representatives, be established within every sizable industrial community" to handle local disputes.

Questions such as the fairness of a particular wage scale, however, are best left to the parties themselves, and as an aid to this "industrial self-government," the Committee recommends the establishment in each industry of a second type of a voluntary mediation board, composed of management and labor representatives alone. The Committee does not go further to say what should be done if this group is unable to agree, but it expresses the hope that more positive acceptance of collective bargaining by both sides and a determination to settle their own problems will reduce the need for government intervention.

The factual findings have little to say on the problems of internal union relations, but the Committee is not deterred by this from making some positive recommendations. In order that the rights of union members are not unjustly abridged by union officials, a majority of the Committee recommends "the establishment of federal and state tribunals to enforce fair union practices and to be known perhaps as fair-labor-practice boards."

Also, it is urged that "all union finances be under law opened to public scrutiny, as many are, and that full reports of receipts and expenditures be prepared, certified, and regularly published." Incorporation of unions, however, is condemned "as an adventure in futility since incorporation is a device to limit, not to increase, liability."

THE UNION SHOP ISSUE

The Committee does not touch directly on the "union shop" issue, which is and will be an important issue in postwar labor-management discussions. In the earlier chapters on "Union Recognition" and "Impact of War," however, the reader is treated to a lively discussion of this issue. "Maintenance of membership," for present union members only, was the wartime compromise imposed by the War Labor Board, but now unions are resuming their demand for the union shop and many employers are seeking a return to "open-shop" conditions.

The authors' conclusion here is significant: "If management showed heartier acceptance of labor's right to organize and exhibited greater willingness to engage in collective bargaining, organized labor would have less provocation to demand 'union security.' But a vicious circle is created by management's opposition to the spread of unionism because of union insistence upon the closed or union shop as security against employer opposition to unionism. That circle cannot be broken except by both management and organized labor—by management ceasing to oppose extension of unionism and by organized labor ceasing to maintain that the union shop is an essential in collective bargaining." It is interesting to note that "few British collective agreements now specify union membership as a condition of employment, and the union shop prevails not by agreement but by custom." The issue is no longer a red herring in British industrial relations, largely because of "British industry's eventual and almost complete acceptance of collective bargaining."

The union-shop issue is not the only topic on which the factual chapters in the book offer a useful summary of recent experience and pungent conclusions on the outlook for the future. In dealing with unions today, the management of a particular firm needs to know and understand what other managements and unions have done on the problems common to all joint relationships. These include such matters as the negotiation and administration of collective agreements, wage differentials, systems of wage payment, hours, work sharing and seniority, and their effect on efficiency, technological change, and union-management co-operation, and they are ably discussed in successive chapters.

THE HUMAN SIDE OF COLLECTIVE BARGAINING

The final chapter preceding the Committee's report is entitled "The Human Side" and should be required reading for those technical men in industry who frequently lose sight of the elementary fact that "workers are people." How this affects the process of collective bargaining is discussed in some detail. "The introduction of collective bargaining into a plant means a great upheaval, and a continuing change, in the very human relations between employer and employee."

The course that these relationships subsequently take depends in a very important sense on whether management adopts a positive or a negative attitude. As the Committee itself later observes, "the attitude of some businessmen that collective bargaining is an unwonted interference with the exercise of their prerogatives, is something to be fended off, or outsmarted, or reluctantly tolerated, rather than a technique for harmonizing human relations, and lifting output and morale, remains—in too many cases—a stumbling block to improvement of management-labor affairs."

A new spirit is called for, the Committee believes, not only on the part of management, but on the part of representatives of organized labor and government who "must become—more consciously than ever before—trustees of other people's money, skills, and aspirations." The Committee's final statement is that "this change in the moral and psychological climate of collective bargaining is vital, necessary, and long overdue."

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Research Laboratories

THE November, 1945, issue of *Architectural Record* places emphasis on the construction of buildings for research, and also discloses the new standards being set by architects, engineers, manufacturers, and builders in completing them, so that our scientists, in their technological hurdle race, have the finest, fastest, most flexible facilities to carry on their research. In his November editorial, Kenneth K. Stowell, editor of *Architectural Record*, says that "public consciousness of the results of research is aroused by the atomic-bomb developments. The public is ready for researchers to continue to produce the impossible."

This new research laboratory building program will challenge architects and engineers to reach new heights of ingenuity, for leading scientists are, at this moment, giving their testimony in regard to research, and the program and facilities for carrying it on.

One of the projects in which architects and engineers have taken many pioneering steps is the Firestone Research Laboratory Building for Firestone Tire and Rubber Company, Akron, Ohio. This laboratory, having had a wartime start, is fully described, with illustrations showing space-use, flexibility, adaptability of facilities, equipment, materials, and processes.

A preview is given of the proposed General Motors Technical Center, a group of buildings designed to bring together the research and experimental facilities of the corporation. This project will be located on a 350-acre site near Detroit, Mich.

The efficient arrangement of areas and facilities of the research laboratory for Hoffmann-LaRoche, Inc., Nutley, N. J., is effectively presented.

Other research laboratories and buildings covered in the November issue are: The new Johns-Manville Corporation Research Center near Bound Brook, N. J., the expansion of the university laboratory of the Georgia School of Technology, Atlanta, Ga., and the proposed "Electronics Park" at Syracuse, N. Y., for the General Electric Company.

Library Bequest

THE Engineering Societies Library has recently received a $10,000 bequest from the late William S. Barstow, noted financier and public-utility executive. This fund has been added to the endowment income of the library.

Mr. Barstow was not only one of the outstanding figures in the field of electrical development in this country, but was well known for his benefactions. In addition to being active in many civic, business, and society organizations he gave generously of his time and resources to the library. He was a member of the Library Board from 1931 to 1942, and a member of the Executive Committee of the Board from 1934 to 1942 when ill-health forced him to resign.

During the years 1935–1938 he gave $7500 to cover the cost of binding and repairing the rare books in the library. In 1940 Mr. Barstow gave $500 for the extension of the services of the library to engineers.

The need for more friends of the library such as William S. Barstow is best summed up by quoting the following from an address delivered by A. R. Mumford, fellow A.S.M.E., at a dinner, May 15, 1939, at the Lotus Club, New York, N. Y., in honor of Mr. Barstow and in appreciation of his interest in the Engineering Societies Library:

"At each of our Board and Executive Committee meetings of the last three years, one subject has always been discussed: How can the library be made of greater service to the engineers? Just as regularly the answer has developed: When we have more money. Strangely enough the library cannot be operated without funds. About $50,000 is now spent each year. Some of that comes from a permanent endowment of $200,000 which ought to be two million, and the rest from appropriations from the membership dues of the Founder Societies.

"Your library provides a technical service not matched elsewhere. With the help of such broad-visioned men as our guest of honor it is slowly extending that service. Through all his life he has recognized that the advancement of the profession both practically and ideally affords as great satisfaction and is as necessary to progress as the completion of an ultramodern efficient generating station. We of the Library Board think of him as our friend and mentor, vitally interested in the advancement of the profession through library services."

The endowment income at the present time supplies about one fifth of the library revenue. If this can be increased by gifts from others with the farsightedness of Mr. Barstow, the library can further extend its services to engineers.

Reintegrating the Veteran

AT a demonstration meeting presented by *The New York Times* in Times Hall, New York, N. Y., Jan. 17, 1946, Dr. Howard A. Rusk spoke on the problem of reintegrating the veteran into his community life. Dr. Rusk, a former colonel and chief of the AAF Rehabilitation Program and now a *Times* staff member, placed the men who return to civilian life into these three categories: The physically handicapped and physically disfigured, the emotionally wounded or psychoneurotic, and the normal veteran.

In receiving our physically handicapped and disfigured, Dr. Rusk said that there is only one rule to be followed and that is not a rule but a simple fact of common sense. Legs, arms, and eyes do not make men individuals, it is the spirit within. It is the same man who returns but he will have changed somewhat because of his disability and he will change even more as he learns to live with his disability and compensate by increasing other skills necessary to carry on his everyday activities and

vocation satisfactorily. If we, who stayed at home, remember only this one cardinal point—recognize the man and not the disability—and use good manners and common sense, then there are no other rules.

As for the emotionally wounded or psychoneurotic, people should remember that it is not insanity, it is not an organic brain disease, and it is not shameful. Dr. Rusk said that fear is normal in every man and also every man has an end point. When he exceeds that end point a breakdown occurs, resulting in the man's being emotionally wounded. The medical profession calls it psychoneurosis. It is highly important for the community to realize there is no set formula for reintegrating individual veterans into community life. Physical exertion, vigorous sports, the reawakening of civilian interests, identification with family, friends, the community, and most important of all, the job, add up to return to normal. Again the simple principles of understanding, good judgment, and common sense are the best guideposts.

The normal veteran, upon returning home, needs some time to settle down. He needs understanding. Service centers where he can get correct and proper information efficiently and courteously are necessary. And then, without doubt, the final answer will be the right job at which he can make a decent living and perhaps utilize some of the things he learned in the service. In helping the veteran find the right job, industry and all of our social agencies must play an important role by exercising good judgment, using common sense, and showing added courtesy toward the returning veteran. Here is where the intelligence, foresight, and planning of the community and industry must assert itself.

Boatbuilding

A SHORT sketch of the new methods of boatbuilding was given by John Owens, Owens Yacht Company, in his paper, "Boats for Your Pleasure, $0.26 per Pound," read before a Wood Industries technical session of the 1945 A.S.M.E. Annual Meeting.

In his paper the author outlined and described the design problems, materials used, production methods, and the materials-handling problems confronting the boatbuilder in manufacturing cruisers on a large scale.

"Straight-line production," said Mr. Owens, "as applied to boatbuilding is far different from those processes experienced in any other factory. It seems to be a combination of the experience of many types of production and the knowledge and use of processes from other plants. Its efficiency is produced by a concentration on and perfection of details. The details and problems of our engineers are very different from most, however, because a 10,000-lb and even a 22,000-lb boat is a large and complicated structure and it has many more parts than most products."

Mr. Owens described the manufacture of a 33-ft cruiser which is made up of thousands of wood and metal parts including a dependable engine, a kitchen with stove, icebox, sink and water supply, a bathroom with shower, and a living room with sofas, tables, venetian blinds, radio, and electric lights. The author said that great advantage was taken of the use of metal castings and fabricated gussets to strengthen joints and carry stresses between two wooden members in order to produce a stronger boat and reduce weight at the same time.

The cruiser weighs about 12,000 lb and sells for $3200 or approximately $0.26 per lb and, according to Mr. Owens, is capable of cruising from Maine to Oregon.

Boron Carbide

THE hardest material made by man, is how Edwin Laird Cady describes boron carbide (B_4C or B_6C) in his article "Boron Carbide—Hardest Man-Made Material" (*Materials and Methods*, October, 1945). Although it is not a new industrial material, boron carbide has been generally neglected since it first came on the market ten years ago, primarily because of its high first cost, its fabrication difficulties, and its design limitations. Recently some engineers have overcome these inherent difficulties and have found the use of this material so valuable that they have kept their techniques company secrets in so far as the manufacturers of the material are concerned.

In the manufacture of boron carbide, water is evaporated from the purest boric-acid crystals to form a glasslike anhydrous oxide. This is combined with highest grade ash-free petroleum coke and heated in a resistance furnace to a temperature approximating 5000 F. The resulting product, boron carbide, is then crushed to a fine powder which can be used for lapping purposes or made into solid shapes by heating to about 4442 F and pressing into shape without use of any binder.

The greatest advantage of boron carbide is its extreme hardness. In this property it is second only to the diamond. Not only is it extremely resistant to abrasive wear, but it is also so

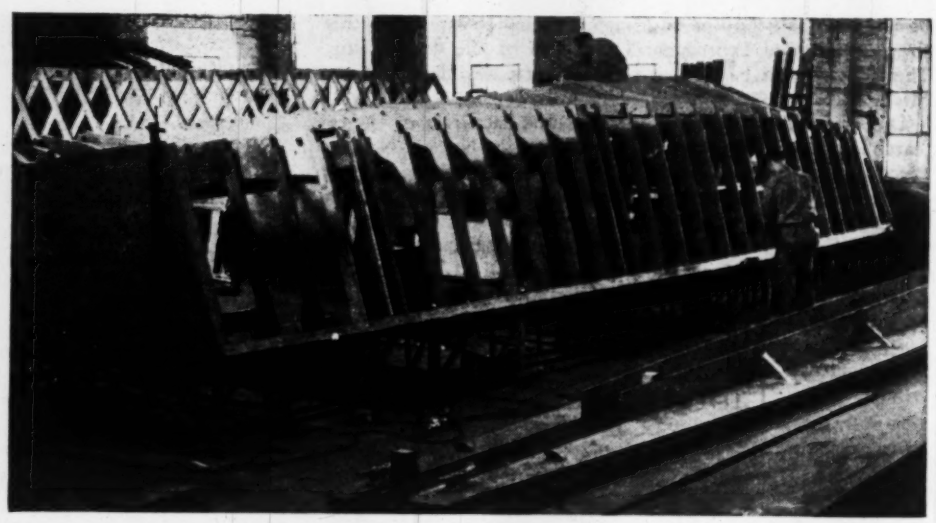

FIG. 1 THE BEGINNING OF MAIN ASSEMBLY IN THE OWENS YACHT COMPANY

(Note steel jig and upside-down construction of hull. Mr. Owens said that work can be accomplished with greater efficiency and less physical effort using this upside-down method. Staging is eliminated and men work on the floor most of the time. Light is also equally distributed over the hull to aid the process.)

chemically inert that it is unaffected by acids or other chemicals. The material cannot be dented, bent, or deformed by any force less than that required to spall or fracture it. On the other hand it is brittle and cannot be designed into shapes with sharp edges or unsupported thin sections. Used in combination with other materials, boron carbide must be carefully mounted and supported.

Price comparison with its only rival—diamond dust—reveals an advantage of boron-carbide powder. Boron carbide weighs only one half as much as a similar bulk of aluminum, and it sells for $6 to $14 a pound in 100-lb lots against the cost of diamond dust of $0.75 to $1.50 per carat. Diamond dust, however, has the advantage in a comparison based on operating speeds; it cuts twice as fast as boron-carbide powder. The relatively low cost of boron carbide does not impose extreme care in its use. It can be used liberally and changed frequently without expensive inspections of the cutting edges of the particles. Since it does not cut as rapidly as diamond dust, it can be used safely on fully automatic machines. Because of these factors the manufacturers believe that boron carbide can promote the development of hundreds of new lapping operations in various industries.

One of the earliest uses of solid boron carbide was for abrasive blast nozzles. In this application the users had a choice between the two extremes of production philosophy. A producer could use ten-cent chilled iron nozzles and discard them as often as one every 30 sec, or he could pay 170 times that price and obtain 3000 times that nozzle life.

Gage parts are among the latest devices being made on a large scale of boron carbide. Mortar linings and pestle tips for laboratory are also a new item. Experiments are currently being made with boron-carbide sleeves for plain bearings.

A few of the other applications are: Masks for glass which is to be sandblasted; axminster needle parts for handling jute thread in carpet mills; abrasive blast-wheel blades; dehydration plants in which hydrochloric acid is sprayed; extrusion dies for abrasive rods, for coating welding rods, and for coating cables for graphite pencil leads; and plugs to set up eddy currents when drying abrasive slurry.

All but two or three of the uses are new. There seem to be many places where solid boron carbide could be used in machine shops, textile mills, chemical plants, foods plants, extrusion processes, glass, ceramics, and plastics industries. In no field in which it has been tried do its ultimate possibilities seem to have been approached.

Electronic Navigation Aids

COAST Guard Headquarters has announced the publication of a booklet on "Electronic Navigational Aids," including a basic description of loran, radar, and racon.

Written in nontechnical language and with over thirty illustrations, this 48-page booklet is being released by the Public Information Division of U. S. Coast Guard Headquarters, Washington 35, D. C. A foreword by Rear Admiral L. T. Chalker, USCG, Deputy Commandant, points out that the Coast Guard operates an extensive system of loran stations and has promulgated suggested specifications for radar equipment.

One portion of the booklet deals with loran and provides a brief sketch of the historical background, a description of the loran system, including principles of operation, the application of loran, a consideration of the operating range and accuracy, a summary of the most valuable features, and a brief discussion of some of the technical aspects.

The second portion of the booklet sketches briefly the history and development of radar, with especial attention given to the study and experimental testing of radar by the Coast Guard. The booklet also contains a technical description of radar and its functional parts, a discussion of the factors affecting the selection of a merchant-marine radar, a brief consideration of future developments, and a glossary of terms most frequently encountered in discussing radar.

Since the Coast Guard is traditionally responsible for developing, installing, and maintaining an intricate system of aids to navigation, and since research and experimental testing in regard to loran and radar have received great stimulus from World War II, this booklet should be of interest to all persons seriously interested in electronic navigational aids and the practical use of such aids.

High-Pressure Pipe Lines

IN order to conduct the service water from Switzerland's rivers and streams to the turbines of high-pressure power stations, special high-pressure piping is needed, and for the past seventy years Sulzer Brothers, Limited, of Winterthur, Switzerland, have played a leading part in the development and erection of such piping.

An article by W. Kienast and Dr. W. Müller in the *Sulzer Technical Press*, No. 2, 1944, gives an account of the planning and development of high-pressure piping in Switzerland in recent years.

PROBLEMS OF PLANNING

Planning of the high-pressure pipe line—the main artery of the power station—is the most important task encountered. First, the most appropriate course and type of line must be chosen. These influence design, methods of manufacture, and erection. The course, first of all, must be adapted to the run of the hydraulic pressure curves. Next come questions of the most economical diameter and its gradation, and the best division and anchoring of the piping. Flow conditions and choosing the most favorable form for the branches must also be carefully studied.

The execution of a high-pressure pipe line depends partly on hydraulic requirements, topographical and geological conditions, manufacture, transport, and assembly. Thought must also be given to the properties of the material and the question of securing it. Finally, the laying method must be chosen.

The laying may be done in several ways—open or covered, in an accessible gallery or in a plate-lined shaft as depicted in Figs. 2, 3, and 5. The line will have one or more pipes, according to the head and quantity of water. Single pipes are made to dimension in the workshops from high-quality steel plate and consist of several sections. When finished, they are transported to the scene of erection by rail, road, water, and cable railway. The dimensions and weights of pipes thus depend not only on workshop equipment and manufacturing process, but also on the means of transport and erection.

Material

The choice of material of the necessary strength and with suitable properties for welding and machining is a major problem. High-pressure pipe lines are made exclusively of steel plate fulfilling definite requirements with regard to quality. The metal employed and the welding done are therefore kept under continual examination.

In special designs strict inspection of the materials is essential, particularly with reference to notch impact strength and sensitivity to aging, as it is chiefly on these properties that the deformation capacity of welded constructions depends.

FIG. 2 AN EXAMPLE OF A PIPE LINE LAID IN THE OPEN, SOME OF THE PIPES BEING RIVETED

(Usually adopted where no question of land cultivation, avalanches, rockfalls, or military defense measures have to be considered.)

Design

Design calculations are directed toward the stresses produced by the internal pressure and the forces acting from the outside. Temperature, transverse contraction, vacuum formation, effects of soil coverings, disposition and measurements of anchorage points, the supporting of pipes, steps taken to prevent freezing and corrosion, all require special elements of design.

Branch pipes require special design and investigation into strength problems on account of the reinforcement need of the weak points they cause.

Manufacture

The conditions necessary for a suitable manufacturing process, apart from workshop and erection equipment, are systematic training of the specialized workman to do a dependable and first-class job, and continual material inspection during manufacture by means of X ray, trepanning, and other tests. Particular care is demanded in the treatment of high-tensile boiler plates, in the execution of special welds and abnormal constructions, and in the application of heat-treatment, on all of which progress and development depend.

Erection

Laying a high-pressure pipe line presents a wide variety of problems arising from the difficulties of terrain and transport, the execution of the joints on site, and questions of individual design.

REVIEW OF DEVELOPMENTS

Up to the year 1925 straight piping was usually riveted, Fig. 2. Besides riveting, it was usual to make anchorage pipes of cast iron or steel, until from 1910 onward welding was gradually introduced for these sections.

Sulzer Brothers used welding for the first time in 1907, and in 1925 riveting was abandoned for the construction of high-pressure piping. All the pipes of the gallery pipe line shown in Fig. 3 are welded.

Electric welding advanced rapidly and has now been predominant for some years in high-pressure piping production, while autogenous welding is adopted in cases for which its properties are particularly suitable.

Table 1 gives an idea of the evolution of high-pressure pipe-line production at Sulzer Brothers with regard to the utilization of material.

TABLE 1

1	2	3	4	5	6
Time interval	Static pressure times 1/2 diam, kg per cm	Wall thickness and plate type, mm	Plates used Size, sq m	Weight, kg	Circumferential stress,[a] kg per sq cm
Before 1900	990	14 MI	9.5	680	760
1900–1910	1760	25 MI	8.2	1040	790
1910–1920	2100	29 MI	16.4	1910	910
1920–1930	3825	49 MI	13.6	2280	880
1930–1940	4320	45 MII	22.7	7850	1100[b]
Since 1940	6000	58 MII	21.7	7250	1220

[a] In solid plate after subtracting 1 mm rust allowance and at static pressure.

[b] Welded seams of special execution, pipes submitted to stress-relief annealing.

In the course of power-station development, increasing quantities of water have to be harnessed, and often from very great heights. The engineer is thus faced with the problem of raising the stress limits of the high-pressure pipe-line metal far enough to obtain optimum economy in service within the bounds set by diameters and wall thicknesses. His main aims must there-

FIG. 3 EXAMPLE OF A GALLERY PIPE LINE

(This method of laying is used mostly for high sites in the mountains.)

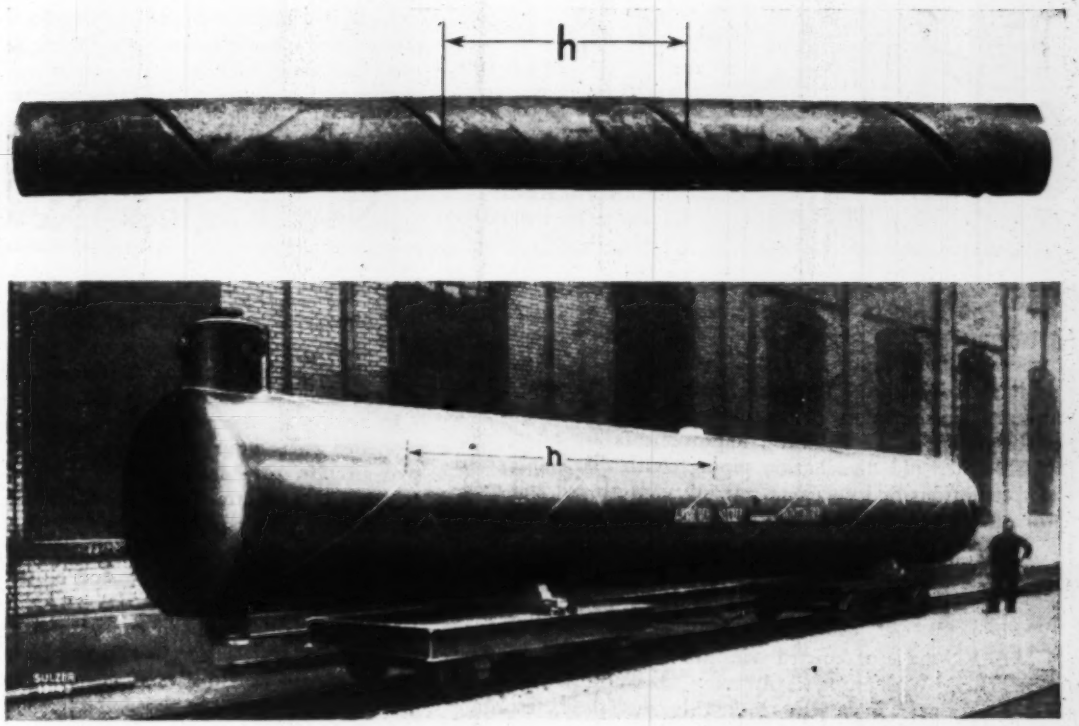

FIG. 4 CONTINUOUS SPIRAL SEAMS DISPENSE WITH DIVISION OF PIPE INTO LENGTHS CONNECTED BY CIRCUMFERENTIAL SEAMS

(They are known as single-thread (*top*) or double-thread seams (*bottom*) according as the full width "h" is formed by one or two strips of metal.)

fore be saving of material, simplification of design, increase of reliability, and reduction of costs of manufacture.

It was these considerations that led to the employment of high-tensile boiler plate and the development of the welded joint. Heat-treatment of finished welded constructions also gives an increased capacity for plastic deformation and thus reduces the danger of rupture. Saving of material can further be achieved by the use of plate-lined high-pressure shafts.

FIG. 5 EXAMPLE OF A PLATE-LINED SHAFT

(Used especially when the power station is built underground. Also economizes material, as the rock of the mountain itself serves to take part of the internal pressure.)

Spiral seams, shown in Fig. 4, were introduced some years ago to replace the longitudinal seam. In pipes subjected to internal pressure the greatest stresses run circumferentially. Consequently, the longitudinal seam is exposed to the main stress. A slanting seam, however, cuts the circumferential stress at a certain angle and is thus subjected only to a component of the total force.

A testable site weld to facilitate erection was introduced as illustrated in Fig. 6 and has been applied with complete success for many years. This method makes the fitting and welding of the pipes simple and reliable, and furthermore the site welds can be easily tested to insure their watertightness.

These testable joints are electrically welded inside and out. The annular space *r* left between the seams *i* and *a* (see Fig. 6) allows water under pressure to be forced in for testing purposes. The testing of the seams follows without interruption in the execution of the weld, the pressure employed being $1^1/_2$ times the service pressure at the point in question. The sleeves are made in bending rolls or on a turning machine according to the wall thickness.

CONCLUSION

This account of the development in the construction of high-pressure piping at Sulzer Brothers illustrates the very considerable progress made—progress which is of great value not only for the projection and building of new plants but also for the renovation of existing pipe lines. The replacement of old lines is indicated whenever leakages or phenomena of aging such as cracks, embrittlement, rusting, rivet wear, erosions, etc., occur. The new electrically welded piping will have less weight and pressure losses for the same internal diameter. In other cases the replacement may be accompanied by an increase of diameter, while in plants with several lines of piping the number of these can be reduced by the use of greater pipe width. In both of the latter cases pressure losses can be cut down and current

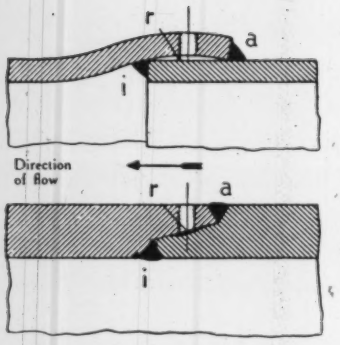

FIG. 6 THE SULZER SITE WELD PERMITS THE PIPES TO BE SIMPLY AND RELIABLY FITTED TOGETHER AND TESTED TO INSURE PERFECT SEALING

(*Top:* Design for wall thickness below 23 mm; and *bottom:* For those above 23 mm.)

production increased. In certain cases again, the head can be increased or the safety of the plant enhanced by reinforcing existing piping. Outstanding improvements are often practicable when old distribution piping, with disadvantageous flow conditions or insufficient reliability, is altered and modernized.

Knitted Wire Fabrics

FABRICS made of knitted wire are new among industrial textiles. With properties differing substantially from those of conventional woven wire cloth, this new fabric, according to an article published in the September, 1945, issue of *Aero Digest* entitled, "New Fabrics of Knitted Wire," will find many industrial uses.

Unlike woven wire cloth in which the mesh must have a definite relation to the diameter of the wire in order to produce a firm product, knitted cloth is free of this design limitation and can be made in a wide range of meshes using a wire of a given diameter.

As a practical illustration of this latitude in design the author says, "It is commonly known to the trade that an insect screen made from 0.010 diameter wire is considered 'sleazy' if it is less than '14 mesh,' having 256 openings per square inch. A knitted wire cloth of good sturdy characteristics can be made from the same size wire which would be comparable to 5 or 6 mesh having 25 to 26 openings per square inch; 230 needle mesh of 0.011 wire weighs $7\frac{1}{2}$ lb per 100 sq ft; 14-mesh wire cloth made from 0.011 wire weighs 12 lb per 100 sq ft."

Although the tensile strength of the knitted wire fabric is not equal to the woven wire cloth, there are many applications where maximum tensile properties are not required and where advantage may be taken of the weight-saving possibilities of the knitted fabric. Large quantities of knitted fabric having 25 openings per square inch and weighing 0.835 lb per 100 sq ft have been used in certain electrical applications.

Where maximum surface effects are desired as in the manufacture of filters, knitted cloth made of flattened wire can be used to advantage.

"A technique of manipulation providing a highly uniform interstitial structure has been developed," the author reports. "The fabric is fluted sharply to give maximum rigidity perpendicular to the plane of the fabric. By fluting on the diagonal and 'crossing the crimps' of each succeeding layer, rather strong metallic structures can be made having as high as 98 per cent free volume.

"In weaving it is common practice to use a partially annealed wire for greater ease of handling. In contrast to this, it is possible to knit fully cold-worked high-nickel alloys as well as the stainless for maximum fatigue values."

Other applications of knitted wire cloth are suggested. For example, resilient masses can be compressed to a controlled free volume, encouraging investigation in the field of shock mounts. The fabric lends itself to use as strainer elements for fluids requiring a high degree of resistance to surge and vibration, and in electrical work the fabric may be used in the form of resilient electric contacts for shielding purposes.

New Engines—New Speeds

AS military censorship is dropped, air-speed records far in excess of the official world record of 469.2 mph, established at Augsburg, Germany, in 1939 by a Messerschmitt 109, have been announced by British and American authorities. Some of the details of the aircraft and engines used for the record runs have also been revealed.

In an article describing the Rolls-Royce "Derwent" jet-propelled aero engine, *Engineering*, Nov. 16, 1945, reports that two aircraft, the Meteor IV, named the Britannia, and the Meteor EE 455 attained average speeds in a series of record runs of 606.25 and 603 mph, respectively. The Meteors, which are twin-engined single-seater low-wing monoplane fighters, were production models and were not built for record-breaking purposes.

While the details of the interior construction of the "Derwent" jet-propelled aircraft engine, series IV, used in the record-breaking airplane are still confidential, information about its general arrangement has already been released.

"It consists of a centrifugal compressor or blower mounted on the forward end of a shaft carrying a single-stage axial-flow gas turbine. The shaft is carried in three bearings and is surrounded by ten combustion chambers which are supplied with compressed air by the blower and fuel (actually paraffin) from a high-pressure pump driven from the engine. The pilot controls the supply of fuel by means of a throttle valve, and an automatic barometrically regulated control is also fitted, to reduce the supply at high altitudes; the latter arrangement is fundamentally similar to automatic boost control used on supercharged aero engines of the piston type. Two ignition plugs are provided to ignite the fuel in starting the engine, and it is stopped by cutting off the supply by means of a high-pressure cock.

Combustion takes place in flame tubes which are mounted concentrically within the chambers and is completed before the gases reach the turbine valve ring at the rear end of the shaft. Initially, the fuel is ignited in only two of the ten flame tubes, but balance pipes between the tubes fire the remaining eight and also serve to equalize the pressure throughout the ten combustion chambers. A triple-gear-type pump supplies lubricating oil to the various bearings, two scavenger pumps returning the used oil through a thermostatically controlled cooler to the oil tank. A small amount of lubricating oil is added to the fuel, the proportion being about one per cent. The fuel and oil pumps, generator, and accessory gearboxes are mounted at the front of the engine, together with an electric starter motor, and the whole is encased in a streamlined cowling having a large intake in the forward end of the nacelle and the jet pipe projecting from the rear end."

AMERICAN RECORD

The U. S. Army Air Force reveals that during a test flight at Farmingdale, Long Island, more than a year ago, a P-47J Republic Thunderbolt powered by conventional propeller-type engine and supplemented by the powerful exhaust of a new type General Electric turbosupercharger to get a jet-propulsion thrust, attained a speed in excess of 500 mph.

Thrust power from the turbosupercharger was obtained by

mounting it horizontally instead of vertically and by reducing the exhaust openings. At its maximum speed, it was stated that 17 per cent of the power developed by the P-47J consisted of thrusts from the turbosupercharger exhaust hood.

Under emergency power conditions the new turbosupercharger permitted the engine to develop approximately 2800 hp at a pressure altitude of 39,000 ft.

Plastic Training Aids

APPROPRIATELY titled is Lieut. Earle D. Roberts' article, "Seeing Is Believing," appearing in the November-December issue of *Army Ordnance*, for in it he tells how ordnance men are trained at the Ordnance School, Aberdeen Proving Ground, Md., using transparent plastic models which allow firsthand observation of what really goes on inside the most intricate pieces of matériel, thus providing the proof of exhaustive theory.

Transparent plastic models of an automotive engine's cooling system, a plastic-sheathed carburetor, carburetor air cleaners, hydrovac brake system, lens and prism setups, complete caliber 0.50 machine guns, and 4.5-in. rockets are but a few of the items employed in this "see-how-it-works" technique.

This system has decreased classroom time considerably since potential mechanics and technicians can witness the actual mechanical operation as it is being explained by the instructor. Instead of visualizing in the mind's eye the working of the automotive engine's cooling system from sketches and diagrams, students now can actually witness the flow of liquid through a complete working plastic model of the mechanism itself.

Because of its durability, plastic can be readily substituted for heavy metals and is equally effective at any thickness from $^1/_{16}$ in. to two inches. Housings are made in varying thicknesses depending on the wear and tear to which they will be subjected in demonstration or actual use. The plastic-sheathed carburetor was installed on a vehicle and used successfully for more than 500 miles.

When subjected to a heat of between 220 and 250 F plastic becomes as pliable as a rubber tube, rendering it easy to shape and bend into any desired form. The plastic material (known technically as methyl methacrylate) can be molded by hand, machined, or threaded, and none of the shavings or extra pieces cut off in the process are wasted. The shavings, when dissolved in methylene dichloride, make a cement which holds sections of models together. When the solution dries there is no trace of it at the points where the sections have been joined.

Besides the use of plastic as a military training aid at the Ordnance School, plastic technicians' courses outlined by the Surgeon General's Department provide instructors to teach hospitalized men, back from the fighting fronts, to make such useful articles as cigarette boxes, picture frames, notebook covers, letter openers, penholders, and candlesticks. Not only is this a pleasant pastime for convalescents but it also introduces them to a remunerative field of postwar employment. Ordinary inexpensive machine and hand tools will equip a small shop, and all the essential information concerning procurement of equipment and supplies as well as publications and references are available.

Future possibilities of plastic are limitless, for it can be twisted and shaped into elaborate and yet useful items. The Ordnance School has pioneered in its adaptation to military training aids and, as investigation and experimentation at the school continue, new fields of application and future importance are constantly being revealed.

Pumping Molten Magnesium

MASS-PRODUCTION techniques in the magnesium casting industry has been made possible by the adaptability of molten magnesium to a pumping procedure which is unique among the common structural metals.

In an article entitled, "Pumping Molten Magnesium," appearing in the September, 1945, issue of *Metals and Alloys*, M. M. Moyle, Magnesium Division, The Dow Chemical Co., describes the procedure of transferring molten magnesium from furnace to mold by means of a centrifugal pump.

Molten magnesium can be pumped readily because of its two properties: Its relatively low melting point (approximately 1200 F) and its inertness to iron and steel at the pumping temperatures.

Mr. Moyle reports that "at the present time commercial use of the pumps is established in alloying processes, alloy ingot casting, continuous billet casting, and wherever bulk metal transfers are required. Molten magnesium is being pumped for distances varying from only a few inches to 25 ft and in capacities ranging from a trickle to a ton a minute. The adoption of reverberatory melting furnaces made possible the melting of large amounts of magnesium since the capacity of these units is around 15,000 lb. Pumping has made large-scale alloy production a continuous operation. From the time the operator charges solid metal into the initial melting unit until another operator takes away a cooled ingot or billet, the metal is stirred and transferred entirely by pumps."

The pumps used for molten metal are of the simple shaft impeller type, powered by an air motor. The pump shaft is sufficiently long (about 60 in.) to keep the motor and the upper bearing away from the direct heat of the metal and at the same time permit the pump inlet to be immersed to the proper depth below the metal level.

Since the pump efficiency is of little consequence, impeller design is devoted primarily to durability and cost economy. If clearances are correctly chosen, almost any standard pump impeller can be used for pumping molten metal.

"Molten-metal pumps have considerably reduced the amount of labor required for metal transfer. Normally, one man can operate a pump during transfer of several thousand pounds of metal. The result is a material saving in cost, but more important during the last few years has been the saving in critically needed manpower, which could then be transferred to other operations.

"Perhaps even more significant than the actual reduction in manpower requirements has been the improvement in working conditions and the change in the type of workmanship required. Physical demands on the men are minimized, since they no longer have to handle heavy ladles of metal nor expose themselves directly to the heat and fumes from the hot settings while stirring or ladling. A good ventilation system effectively takes care of all heat and fumes. As a result, the work will appeal to a higher class of worker who will take an interest in producing good products quickly and efficiently. In these continuous processes involving pumping, control is maintained through regulating instruments and devices, greatly simplifying the maintenance of high quality.

"Closed system operation, besides providing an easy method of avoiding oxide and flux inclusion, contributes to the safety of the process. The elimination of handling of molten metal by workers has greatly reduced the danger of molten-metal accidents.

"Finally, pumping of magnesium has made possible a production speed many times higher than that formerly obtainable with the same melting and mold equipment."

Shotpeening

SHOTPEENING is a method of stretching the surface of a metal by a rain of metallic shot thrown at high velocity. Each shot acts as a tiny peen hammer making a small indentation in the metal surface and stretching it radially as it strikes. Stretching of the external surface in a 0.005 to 0.010 in. layer places it in residual compression while the substance not being deformed is in a state of tension.

Laboratory tests and observations in service of parts subjected to this treatment show that shotpeening increases the life of such parts. In the case of springs and automobile parts it has been reported that increases in life due to shotpeening range from 3 to 20.

In an article, "Shotpeening—Some Outstanding Applications," in the October, 1945, issue of *Materials and Methods*, Henry Fishbeck and Phil Schmitt describe some modern applications of this process by Pratt and Whitney Aircraft, East Hartford, Conn.

Although it might seem that the rough surface of peened steel must set up localized stress concentrations, there is actually a lowering of stress concentration at any one notch or pit by the presence of other notches or pits near-by. Many notches or pits close together seem to share the stress concentrations among them, while an isolated pit has no such relief from the full stress concentration.

Shotpeening can be applied to irregular shapes in which heat-treating processes might cause excessive distortion and in which rolling or drawing processes are not feasible. It can be applied to finished parts or to specific areas on structural and machine parts, for example, to the fillet of a shaft, to offset stress concentration, or to the body, to resist pitting corrosion. It can be applied to gear teeth without appreciable distortion. Often it can be used as a surface finish in place of polishing, with gain in fatigue strength and less production cost.

Pratt and Whitney engineers prefer air-blast peening when it is desired to direct shot at definite small areas and mechanical or centrifugal peening for large surface areas. An essentially practical device is used to check the necessary amount of peening because overpeening is decidedly harmful. Preliminary peening is conducted on a test strip of steel of 44–50 Rockwell C hardness to determine the size of the blast nozzle to be used, the angle of the stream against the work, the air-blast pressure, and the number of minutes of exposure.

The blast nozzle is made of Norbite, trade name of boron carbide, an ultrahard material made by Norton Company, Worcester, Mass. Two kinds of shot are used, chilled cast iron and "Mallabrasive," which is softer than chilled cast iron and is used for peening the softer nonferrous metals.

In the Chicago plant of the Burton Auto Spring Corporation, the peening machine is used 10 hr a day, six days a week. An average of 25,000 lb of springs have been peened daily for more than a year at a cost of under $^1/_2$ cent per pound. The springs for heavy-duty trailers range from 10 to 60 in. long and weigh from 3 to 32 lb. According to the American Foundry Equipment Company, in one case, a 15-sec exposure to 75 lb of No. 25 steel shot increased the fatigue life of leaf springs up to 1000 per cent.

Shotpeening, however, cannot be considered as a cure-all for such surface defects as harmful magnaflux indications, toolmarks, and sharp edges. Harmful magnaflux indications are not eliminated by peening. Toolmarks will show more prominently after peening, but the part peened will be a much stronger part if the shot used is of a size that will peen the root of the toolmark. Sharp edges on parts before peening will not be removed by this process because peening does not remove metal. Sharp edges should be removed from the part before the peening operation, otherwise a rolled edge will result; but should a rolled edge be allowed in the part, the peening should be done so that the edge is rolled away from the tension side of the piece.

Pressure Combustion

AN optical method for measuring the temperature of fuels burning under pressure and some of the results obtained by use of this method in connection with an automobile cylinder using various compression ratios and different fuels is described by J. G. Coutant in an article "Pressure Combustion" (*Southern Power and Industry*, December, 1945).

By means of a technique known as "Fery's Reversal of Ray From Sodium," the flame within the engine cylinder is given luminosity and color by the addition of sodium alcohol or sodium ethylate to the fuel, and the temperature of the flame is measured with an optical pyrometer by comparing the flame color against the color of a calibrated light source.

The method (see Fig. 7) consists of light source T whose intensity can be controlled and whose temperature has been calibrated. Rays from T pass through the lenses L_1 and

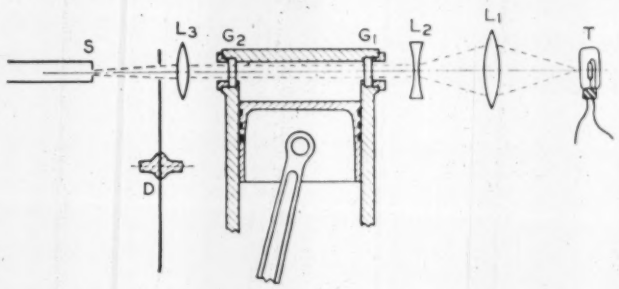

FIG. 7 SCHEMATIC SKETCH OF THE FERY METHOD OF MEASURING TEMPERATURE OF FUELS BURNING UNDER PRESSURE

L_3, then through the quartz windows G_1 and G_2, built into the test cylinder. The rays continue through lense L_3, pass through the synchronized stroboscope D which rotates at one half the engine speed, and finally enters an optical pyrometer S. When the cylinder flame is observed through the optical pyrometer a reversed sodium line and color is seen against the background of continuous color of light source T. The temperature of the cylinder flame is obtained by comparing the color of the sodium line with the color of the calibrated light source.

Use of the Fery method in England and France revealed that temperatures much higher than those used by engineers for design purposes occur within the engine cylinder. A temperature of 4316 F for benzene, 3923 F for cyclohexane, 3802 F for city gas, and 3383 F for iso-octane has been observed at the high dead-center point of an engine operating at a compression ratio of 6.7/1 (95 psi abs). These data reveal how the maximum combustion temperature varies for various combustibles having different velocities of combustion and adiabatic compressions.

Tests have shown that with the same fuel higher temperatures are obtained with the use of higher pressures. The influence of compression ratio on temperature was demonstrated when an engine operating at 2000 rpm using aviation gasoline as fuel gave a maximum temperature of 4352 F with a compression ratio of 6.7/1 but a maximum temperature of 4082 F when the compression ratio of 5.44/1 was used.

Because cylinder temperatures fall rapidly at beginning of the stroke, Mr. Coutant suggests that new economies with the

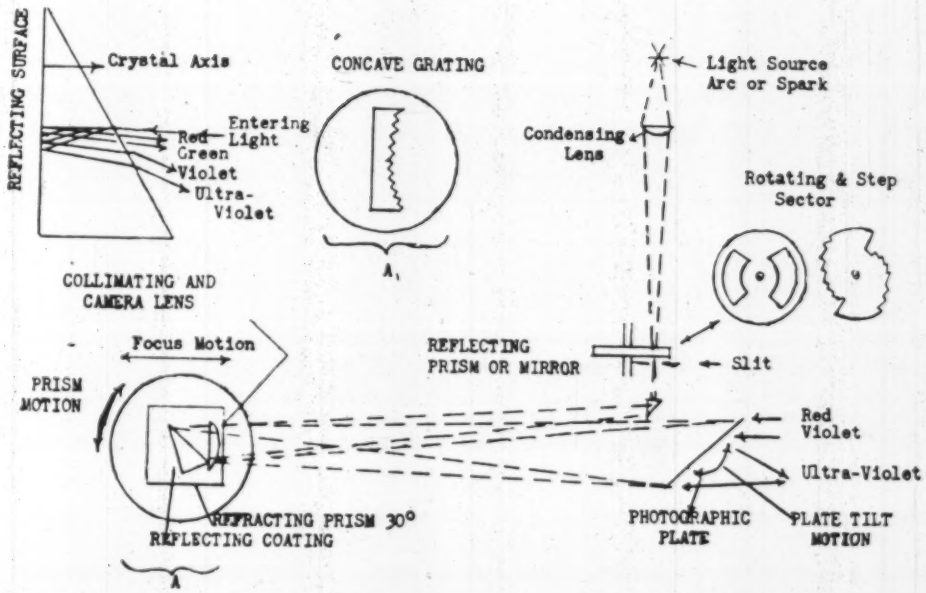

FIG. 8 SCHEMATIC SKETCH SHOWING THE ARRANGEMENT OF THE LIGHT SOURCE, SLIT, DIFFRACTING LENS OR DIFFRACTION GRATING, AND THE PHOTOGRAPHIC PLATE OF THE LITTROW TYPE SPECTROGRAPH

internal-combustion engine lie in the direction of higher operating speeds. The newer ideas for heat engines involve rapid utilization of the heat generated within the engine.

Spectroscopic Analysis

FOR quick and accurate chemical analyses of ferrous, nonferrous, and nonmetallic materials, Wm. J. Poehlman, in an article "Spectroscopy Applied to Ferrous and Nonferrous Materials," *The Welding Journal*, November, 1945, recommends the use of the spectroscopic method. By use of the spectrograph, nondestructive analyses of metals, castings and forgings, bars, and plate stock, weld-rod wire and weld metal can be procured with great speed and accuracy. As a modern laboratory analytical tool, the spectrograph serves the demand for increased production by affording a simple and mechanical laboratory routine which can be safely entrusted to laboratory assistants. Today spectroscopic methods are being utilized in such fields as ceramics, glass, food, organic and inorganic chemistry, biology, agriculture, mining, medicine, and in all phases of metallurgy.

PRINCIPLES

The principles of spectrochemical analysis are based upon the fact that the atoms in each chemical element, when converted to a vapor state by suitable thermal or electrical excitation, vibrate with a characteristic frequency. These frequencies can be measured and recorded by studying the spectrum formed when an element is introduced into a source of light and the light dispersed by passing it through a lens or a diffraction grating. An element or chemical compound can therefore be identified by comparing the spectrum it forms to the standard spectrum of most of the elements and common compounds available to any laboratory.

The spectrograph is the principal instrument used in spectrochemical analysis. By combining the principles of physics, optics, and photography, this instrument produces a photographic record of the frequencies emitted by the atoms in the specimen under analysis. Essentially, the spectrograph consists of an arc or a spark which brings some of the atoms of the specimen into suitable excitation; slit, which converts light into a narrow beam; a lens or a diffraction grating, which disperses the beam of light into its components; a focusing lens, which brings the dispersed light into focus so that the component wave lengths are arranged in the order of their wave lengths, thus forming a spectrum; and finally, a photographic plate or film which registers as a permanent record the spectrum thus formed. A schematic sketch of the Littrow type spectrograph is shown in Fig. 8.

While the complete electromagnetic spectrum covers a range of wave lengths from the longest radio waves several miles long to the shortest gamma rays of one million-millionth of a centimeter in length, spectroscopic analysis concerns itself only with that small portion of the known spectrum which evokes colors in the human eye. The visible spectrum is evoked by waves ranging from 760 millimicrons (millionth part of a millimeter), which register as red light, to 385 millimicrons, which register as violet light.

HISTORY

The spectroscopic method is based on the fundamental discovery by Sir Isaac Newton in 1666 that white light could be resolved into its component colors by passing a beam of light through a glass prism. It was further advanced by William Hyde Wollaston in 1802, who discovered that the spectrum of sunlight was not continuous but was crossed by dark lines. In 1817 Joseph von Fraunhofer invented the diffraction grating, the second method of forming a spectrum. By placing a convex lens between the light source and the diffracting lens, he constructed the first spectroscope and was able to prove that the spectrum lines formed from a given source of light always occupied the same relative position. A few years later, J. F. W. Herschel made the first systematic observations of metallic emission spectra. While investigating the spectra of colored flames, particularly those charged with copper and strontium, he attempted to record graphically the relative position of the lines, and thereby laid the foundation of spectrum analysis.

While quantitative determination by the spectroscopic method of analysis was well established by the turn of the

twentieth century, the lack of a photometric method of sufficient accuracy to measure the relative intensity of spectra lines defeated all attempts at qualitative determinations. As late as 1910 it was generally considered that such determinations were impracticable.

Since 1925, however, incredible progress has been achieved, and today the spectrochemical method stands up to advantage when compared with wet chemical or colorimetric methods of analysis. During this period international standardization of wave-length measurements and tables has been established, spectrographs have been improved, excitation methods and photographic materials have been perfected, and microphotometers have been developed, all of which have helped to reduce the early limitations of quantitative determinations.

ADVANTAGES OF METHOD

Mr. Poehlman, who is chief spectrographer of the A. O. Smith Corporation, Milwaukee, Wis., where the spectrograph has been used as a research and analytical inspection tool continuously since 1928, lists the following advantages:

(1) *Speed.* The time required for spectroscopic analysis ranges from eight minutes to one hour, depending upon the nature, size, and preparation of sample and the number and kind of determinations reported. Under routine analysis techniques, eight to ten determinations per man-hour can be easily attained.

(2) *Accuracy.* At the present state of development, precisions of three to five per cent standard deviation are obtainable.

(3) *Cost.* For the same number of determinations per sample, the cost is less. A saving of approximately ten times over the cost analysis by other methods can be attained by the spectroscopic method.

(4) *Sensitivity.* Some elements can be detected in amounts lower than 0.0001 per cent, while some metallic elements can be identified when their concentration reaches 0.001 per cent.

(5) *Simplicity.* Routine can be easily mastered by laboratory assistants. The 16 rare earth elements, which are especially difficult and tedious to analyze by wet chemical methods, can be easily determined.

(6) *Sample Size.* Never need exceed 100 mg.

(7) *Permanent Checks and Records.* Since the spectrum is obtained on a photographic plate or film, the analysis can be reached at will and filed for future reference or study.

(8) *Nondestructive Tests.* By use of a flat-surface sparking technique, analyses can be made on finished products without destroying or obtaining drillings for a complete determination of all elements except carbon, phosphorus, and sulphur.

(9) *Detection of Unaware and Residual Elements.* Determination of such elements are valuable in all analyses, but the chemist usually reports only those elements or analyses specified. The spectrographer records all elements present in addition to those required or suspected.

DISADVANTAGES OF METHOD

(1) Analysis of certain of the nonmetal elements such as oxygen, nitrogen, chlorine, or sulphur can be determined more satisfactorily by other methods.

(2) Certain analyses can be carried out more quickly by the wet chemical or colorimetric method.

(3) Some quantitative determination of elements that occur in high concentration are better by other methods.

(4) There are only a few widely acknowledged spectrographic standard samples available at present. The kinds and types are limited and additions to them are a slow process.

APPLICATION TO PRODUCTION PROBLEMS

In addition to its use in many regular daily routine spectrochemical analyses, spectrography can be applied to an endless number of chemical and metallurgical research and production problems. This broad utilization is possible by co-ordination through the other laboratories. A résumé of such trouble-shooting applications include the following:

(1) Excessive hardness or softness, hot shortness, improper ductility, and variations in physical qualities.

(2) Causes for accelerated corrosion, intergranular corrosion, and cracking.

(3) Identification of mixed steel, dirty steel, inclusions and residuals, and failure to meet or pass inspection or specification requirements not here mentioned, such as electrical resistivity, stress, magnaflux, and X ray.

CONCLUSION

Residual elements and inclusions are on the increase and in all probability will continue to increase as the close scrutiny of war inspection departments is removed. The contamination of carbon and steel scrap with alloy scrap is becoming a serious problem. Dealers and producers seem to be unwilling to make proper segregation or maintain large inventories. The pressure to keep alloy-steel scrap moving back to the steel mills results in an increase in the mixture of these grades. Some alloy-steel scrap is marketed below carbon-steel scrap prices, thus losing the incentive of maintaining proper segregation.

The control of such elements as titanium, tantalum, arsenic, antimony, zinc, cadmium, bismuth, boron, beryllium, zirconium, cobalt, columbium, lead, tin, tungsten, and others, because of their effect on welding, requires close observation. The spectrographic methods of analysis are admirably fitted to fill these requirements. The postwar period in all probability will be one of high competitive markets, necessitating even closer tolerances and finer distinctions than now prevail. The utility of the spectrograph in research, product development, and manufacture may be expected to find wide application.

Tropicalization

TROPICALIZATION, the treatment of goods and equipment for service in hot and humid places, was a word that acquired wide use among supply people during the war. Damage from mildew had long been a serious problem in the textile industry and the need for a solution to the problem became imperative when the tropical islands of the Pacific were invaded. Tents and tarpaulins failed at an unprecedented rate. Knapsacks and other articles of equipment which were commonly exposed to the elements deteriorated rapidly and literally fell to pieces.

The December, 1945, *Rohm and Haas Reporter* tells how improved methods of mildew-proofing had to be discovered to prevent serious damage to military goods en route to our fighting fronts.

A practical means of mildew-proofing the many different textile items demanded by the war became one of fundamental importance. Several materials offering some protection were developed, but none was universally satisfactory. Some of the more effective products were found to be toxic, producing dermatitis when in contact with the skin. Others inhibited the growth of cellulose-destroying mildew satisfactorily, protecting the goods from damage, but failed to prevent the formation of certain other molds, harmless to the goods in the garments or equipment, but repulsive to the users. In some cases protection could be provided satisfactorily for the cloth, but failed in the thread with which an article was stitched.

A solution to the problem came from the textile laboratories of Rohm and Haas, where the search for a more satisfactory

mildew-proofing agent had been going on for years. A new fungicide, called Hyamine 3258, was in the final testing phase of its development in the early years of the war. Having proved its effectiveness in laboratory and field tests, it was released to the trade for use in military applications. Under these severe conditions of use, it gave full satisfaction.

Chemically, the material is described as a fully substituted quaternary ammonium pentachlorophenate. In the concentrations used in treating fabrics it is colorless and odorless. It is free from toxic tendencies and has been accepted by the Surgeon General's office as a nonirritant to the skin at the concentration recommended.

Hyamine 3258 is a water-soluble material, a feature which makes it easy to apply with any type of dyeing machinery. Textile fibers, immersed in a Hyamine 3258 solution, absorb the fungicide from the bath and retain it so tenaciously that it is not removed by subsequent leaching action of water. For this reason Hyamine 3258 was found useful in applications such as the mildew-proofing of sewing threads for tent and tarpaulin canvases, knapsacks, and other articles of equipment. Since soap has a detrimental effect on the fungicidal action of the material, Hyamine 3258 is not recommended for permanent protection of articles which are subjected to repeated launderings.

This dependable protection has been found remarkably effective, giving the full protection required by military specifications for mildew-proofing materials. The ease of application and long-lasting effectiveness of Hyamine 3258 in its war role promise greatly expanded peacetime uses.

Salt—For Better Gasoline

SALT, one of the basic raw materials used in the manufacture of ethyl fluid, has, since early times, been associated with value and worthiness. It is the most common mineral in existence and one of the earliest substances known to man.

An article in the December, 1945, issue of *Ethyl News* reveals some of the historical background of salt, such as the part played by salt in religious ceremonies, in superstitious beliefs, in medicine, and even in money.

As to the manufacture of salt, old manuscripts reveal that 5000 years ago in China salt was obtained by boiling and evaporating the ash from seaweeds. In America scarcely a hundred years ago, Indian tribes living near the ocean evaporated sea water in open trenches. Those living inland obtained salt by boiling and evaporating the brine from salt springs which buffalo and deer were in the habit of visiting.

Little change was made in the method of salt manufacture through the ages until 1886, when Joseph Duncan, an American, started a salt company at Silver Springs, N. Y. He employed a revolutionary process—the vacuum-pan process—which is still in use today. This method produces a uniformly grained salt of very high purity.

Wells are bored and water is piped down to salt strata in the earth. The resulting brine is pumped up, filtered, and purified. After evaporation in vacuum evaporators, the salt is drawn off and conveyed to driers. It is then screened to separate crystals of different size used for various food and industrial purposes. Besides evaporation, salt is also mined.

The more civilization has progressed, the more demand there has been for salt. Today more than four million tons of evaporated salt are required annually for the home and for a vast number of farm and industrial uses. In the curing of hides and skins for leather alone, 300,000 tons of salt are used annually. In the manufacture of rayon, caustic soda is employed, which is obtained from salt.

In so far as human needs are concerned, nutritionists estimate that adults require about half an ounce of salt per day, or 12 pounds per year, to enable the various glands to hold the amount of water they need for proper functioning. During hot, humid weather, people consume salt tablets to replace the body salt lost through perspiration, and thereby ward off fatigue. Salt is also the source of an important component of gastric juice, both in the human and animal body. Upon receiving salt, the stomach changes its chloride component into hydrochloric acid in order to digest its food. The body divides the salt into its chemical constituents with the greatest of ease, but it takes elaborate equipment to do the same thing industrially. A good example of this is seen in Ethyl's plant in Baton Rouge, La.

There, salt in the form of brine is pumped in from wells 20 miles away. Since brine consists of salt and water, it is first necessary to remove the water in order to obtain the salt. This is done by evaporation, in which the water is boiled off under a high vacuum by heating it with steam. The salt then crystallizes out to form a slurry or magma, which is pumped to filters which separate the salt from the liquor. After leaving the filters the salt passes into gas-fired driers where the last traces of water are removed. The purified salt is then delivered by conveyers and elevators either to the salt storage bins or directly by conveyers to the electrolytic cells, where it is charged.

This "electric chair" treatment decomposes the salt into its two elements, sodium and chlorine. The sodium is then used to form an alloy with lead, while the chlorine enters, among other things, into the manufacture of ethyl chloride. The final reaction of ethyl chloride with the lead-sodium alloy yields tetraethyl lead, the active ingredient of Ethyl fluid, which improves the antiknock quality of gasoline.

Besides its use in the manufacture of Ethyl fluid, salt has innumerable other industrial uses, both of itself and for its two elements taken separately. Sodium is employed in the manufacture of dyes, insecticides, and photographic materials, and in the treatment of metals. Chlorine, aside from purifying water, is used to make hydrochloric acid, the "work-horse chemical," and enters into a host of other industrial uses. As for the salt itself, besides its use to flavor and preserve food, it is used as a gargle, and as an important constituent of some dentifrices, and figures in many drugs, pharmaceuticals, and vitamins. And as many uses as have been found for this age-old substance, the research chemist is finding still more.

Wire Recording

AT a press conference held in the Hotel Piccadilly, New York, N. Y., Jan. 22, 1946, the Wire Recorder Development Corporation, a subsidiary of the Armour Research Foundation of Illinois Institute of Technology, unveiled a number of new developments in wire recording.

The Armour magnetic-wire sound recorder and reproducer feeds a spool of 0.004-in-diam stainless-steel wire from one reel to another through a series of guide pulleys, the wire passing through a magnetic recording head in the process.

There is no stylus or other mechanical device in the recording head. The input of the microphone is converted electronically into a magnetic field through which the wire passes. This field magnetizes the wire and leaves a reproducible magnetic record of sound fed into the microphone.

In the recording head the wire passes through a small slot cut along the side of a laminated core. A 0.002-in. gap is cut in the core in a plane at right angles to the axis of the slot. The magnetic flux traverses the wire longitudinally at this gap.

Electrical compensation to correct for frequency response is incorporated in the amplifier preceding the recording head and is used during the recording process.

When the recording operation is finished the record can be played back without processing, by reversing the motor and rewinding the wire on the first reel. Then, to play back, the wire is run through the recording head in the same direction as when recording the sound. The recording head acts as a pickup and reproduces the sound.

A demagnetizing coil, also in the path of the wire and placed so that the wire reaches that point before entering the recording head, can be energized by throwing a switch, thus removing the sound from the wire. As the wire passes, any message already on it is blanked out by a high-frequency electromagnetic field which leaves the wire in a magnetically neutral state. Simultaneously, as the wire enters the recording head, a new message can be recorded.

Some of the advantages of magnetic wire recording are said to be: No needle scratch—very low noise level; no break in continuity due to changing records or turning them over; it is unaffected by extremes of temperature that affect other methods of recording; it is comparatively unaffected by external vibration and severe shock; unlimited re-use of wire; instantaneous playback without processing; a minimum of background noise; unlimited number of playbacks; longer recording time; it plays and records in any position; excellent fidelity without elaborate precautions or special skills in recording; lightness, compactness, portability; any portion of record can be erased or altered without harm to adjacent portions.

During the war all magnetic recorders were manufactured for and used by the Armed Forces. However, some of the important applications projected for peacetime industrial, educational, commercial, and entertainment uses are: Home and field recording sets; radio-phonograph combinations for recording and playing professional records; speech training, lectures, language, and other courses; dictation and transcription; police calls and reports; transportation communication; sound with slide or motion pictures; broadcasting and remote pickup; court reporting; signal systems; transmission of graphics; and advertising.

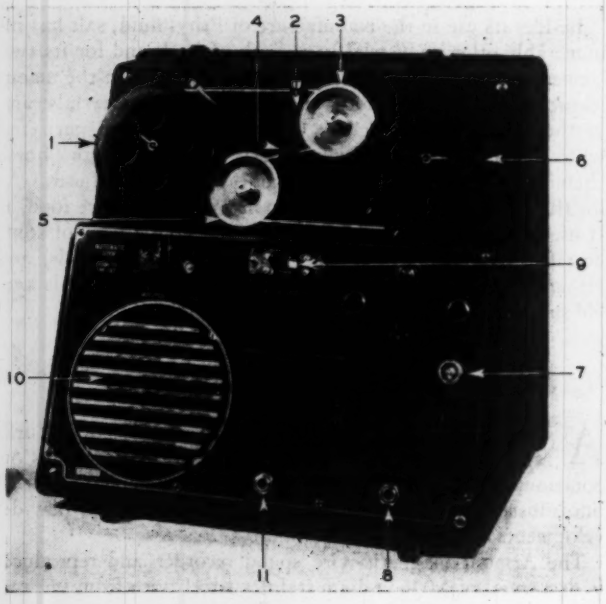

FIG. 9 THE MODEL 50 FOR BOTH RECORDING AND REPRODUCING

(The wire travels from spool (1), through a demagnetizing coil (2), around pulley (3), through recording or sound head (4), around lower pulley (5), and finally winds up on the right hand spool (6). The microphone may be attached to the connection at (7) or a radio receiver plugged into the jack (8). The motor switch (9) controls the direction of wire travel so that wire either passes from spool (1) to spool (6) in recording or reproducing or reverses to wind up on spool (1) preparatory to recording or reproducing. A five-inch speaker (10) is built into the record; however a larger speaker may be used by connecting it to jack (11). Volume and tone controls and automatic tuning and stop device are also provided.)

Metallurgy

Molybdenum

LIMITATIONS on the production of molybdenum in "chunks" of large size and multiplicity of shapes are reported to have been removed by Westinghouse engineers. Furthermore, the cost per pound has been reduced to roughly one third. Oddly enough this feat of major significance in the metallurgical world has been accomplished within recent months in the company's Bloomfield, N. J., plant devoted to the manufacture of lamps and electronic tubes.

The very qualities of "moly" that have seemed so long attractive to designers have been the ones to block its production in large sizes and complex shapes. Moly melts at 4748 F (iron, 2800 F; copper, 1976 F). Thus, although pure moly in powder form can readily be prepared from its natural oxide, it cannot be melted like other metals to form large solid pieces because any container or crucible of known materials would melt first. Thus in the past molybdenum pieces have been made by compacting moly powder into the desired shape under great pressure and then passing a high current through the piece to bring its temperature up just below the melting point, so that the particles rigidly adhere to each other. This method has obvious limitations, both as to sizes and shapes.

Advances have been reported in a new process that removes the restrictions of both size and shape. The piece can have any desired shape that can be molded. It can be round, square, with fins, or angles, or holes and with much larger over-all dimensions than heretofore possible.

The excellent properties of moly are now available for a variety of uses. The most important characteristics are its high melting point and great wear resistance at elevated temperatures. Also, it has a higher modulus of elasticity, increased strength when hot, and better thermal conductivity than any steel. It is lower than the steels in specific heat and coefficient of expansion. Its corrosion resistance compares favorably in many media with tantalum, palladium, and platinum, each costing many times more than molybdenum.

Moly is now proving valuable in the form of crucibles, electronic-tube parts, electrical contacts, electrodes for resistance-heating of glass, welding tips, thermocouple tubes, and for electric-furnace heating elements for high-temperature work in a vacuum or protective atmosphere. It is expected to be useful for welding alloys and high-temperature engine parts.

Stainless "W"

The release from war restrictions of Stainless "W," a new heat-treatable stainless steel of the 18-8 type, which makes available the high strength and corrosion resistance of 18-8 in all wrought and cast forms, regardless of size or shape, is announced by Carnegie-Illinois Steel Corporation, a subsidiary of United States Steel Corporation. In this new steel, developed and now made public for the first time, the basic composition

is so balanced as to insure, without the necessity of cold working, the approximate completion of the austenite-to-ferrite (martensite) transformation and the subsequent process of precipitation hardening.

In the annealed condition Stainless "W" ordinarily has a hardness of 22 to 28 Rc, a tensile strength of 120,000 to 150,000 psi, and a yield strength of 75,000 to 115,000 psi. By proper heat-treatment the hardness can be raised to 39 to 47 Rc, the tensile strength to 195,000 to 225,000 psi with a yield strength of 180,000 to 210,000 psi.

The important element is titanium, which serves the dual purpose of being the primary precipitation-hardening element and a strong ferrite former. With all other elements properly balanced, the optimum percentage of titanium has been found to be in the range of 0.40 per cent to 1.00 per cent. In melting the material, aluminum is added to the bath primarily as a deoxidizer. The excess that remains in solid solution serves to augment the titanium in the precipitation-hardening role. Carbon does not contribute directly to the precipitation-hardening reaction, as do the other preceding elements, but it serves to control the amount of soluble titanium that will be available for the reaction. Nitrogen behaves in much the same manner as carbon because it also combines with, and thus immobilizes, the titanium. It also stabilizes the austenite and therefore should be controlled and held as low as possible (to residual amounts).

The remaining alloying elements, nickel, manganese, chromium, and silicon, serve to control the austenite-to-ferrite balance; the first two elements are austenite formers while the latter two are ferrite formers. It is believed that these elements, with the possible exception of nickel, do not enter into the precipitation-hardening reaction. Columbium has been successfully substituted for titanium to produce precipitation hardening.

Many applications are foreseen for this new steel, particularly in bar form. It is producible in all forms for commercial use, and of particular interest is the fact that it exhibits considerably less directional properties than cold worked 18-8. Although this new steel is stiff to work, it can be subjected to drawing operations and given an intermediate anneal as often as desired in the course of deep drawing, and then heat-treated, to develop the desired high physical properties in the whole piece.

This new steel can be processed successfully in standard equipment and no difficulty will be experienced with warping or dimensional changes in the course of heat-treating operations. It is readily fabricated by spot-welding, and high joint efficiencies can be secured by metallic arc, atomic hydrogen, and heliarc welding operations, particularly when solution annealing followed by aging is employed as a postwelding treatment. Machinability, according to shop tests, is slightly better than that of austenitic 18-8 stainless steel. Unlike most other types of 18-8 stainless steel, Stainless "W" is strongly magnetic.

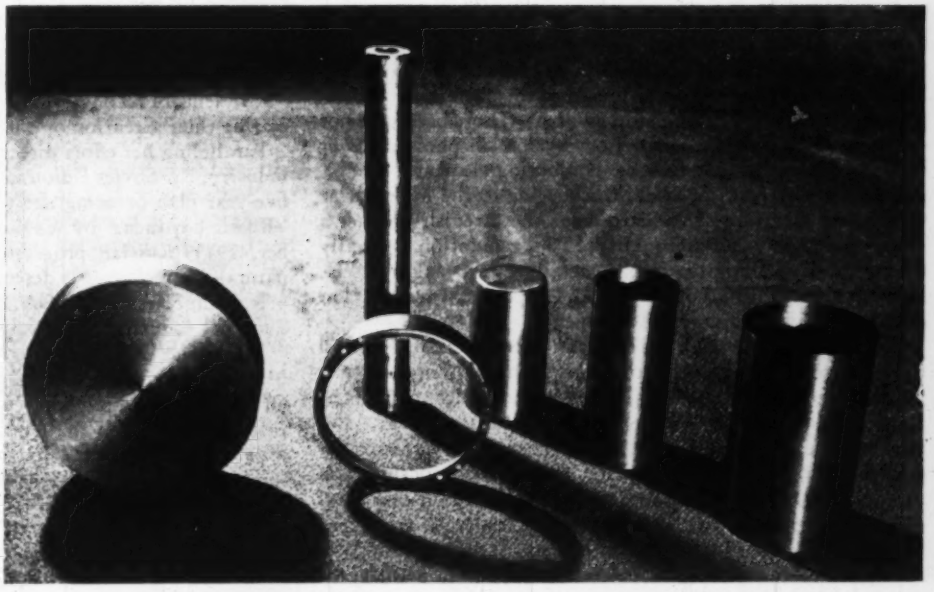

FIG. 10 VARIETY OF PRODUCTS MADE OF MOLYBDENUM

Preliminary commercial applications of Stainless "W" indicate its usefulness in those cases where hardness plus corrosion resistance is essential, as in cams and rollers, in food handling and bottling equipment, bearings, and parts for valves subjected to service in the oil, chemical, and food industries. Other applications involving high strength alone, or in combination with hardness and corrosion resistance, can also be filled successfully with Stainless "W," which is unique in that it can be hardened uniformly throughout unusually heavy sections without difficulties normally attendant upon quenching and surface hardening.

Stainless "W" can be rolled into billets, bars, sheets, or shapes, drawn into wire, or pierced for tubing, or it may be forged as desired into any shape or size, the finished product being amenable to heat-treatment to develop the desired hardness in addition to corrosion resistance superior to that of the heat-treatable straight chromium steels and approximately the same as that of 18-8 stainless steels in most corrosive media.

Swedish Steel Industry

In a move to lessen its dependence upon foreign sources for commercial grades of steel and having plenty of iron ore, Sweden, relates the December, 1945, issue of *Steel Facts*, began a program of expanding its steel industry during World War II. The outbreak of the war cut off Sweden from virtually all sources of foreign supply except Germany, and even this source dried up by 1944. However, plans had already gotten under way for expanding output of finished rolled iron and steel products in Sweden from the 885,000 tons produced in 1943 to at least a million tons.

Since the supply of scrap iron and steel in Sweden is limited, expansion of steel production rested mainly on expansion in pig-iron producing capacity. A new plant was built near Lulea in the northern part of Sweden, consisting of three blast furnaces in which electric energy is the main source of heat. In addition, steel-melting furnaces, rolling mills, and other finishing equipment were constructed.

Sweden has long been noted as a producer of high-quality products for most of its 600 years as an ironmaking nation. For a time, too, it was one of the leading producing countries in the

world, although now Sweden produces less than one per cent of world output.

The principal reason for Swedish superiority in producing high-quality products was attributed to the chemical composition of certain iron ores found in Sweden. Those ores were not only rich in iron, they were also very low in phosphorus or even almost free of that steel-contaminating element. The inherent characteristics of Swedish iron, due to the high purity of the raw materials, have earned for the Swedish product a world-wide reputation for quality. That reputation is equally merited today. Progress in the metallurgy of making steel, however, now permits countries with less pure raw materials to overcome their material disadvantages.

Currently most Swedish ore comes from two sections—central Sweden, which supplies the low-phosphorus ore on which the domestic industry is based; and the Lapland fields, north of the Arctic Circle, yielding high-phosphorus ores for export. Reserves in the former area have been estimated adequate to support the industry for 75 to 80 years of the average consumption during the 1933–1942 period. It has been estimated that total deposits in Lapland will last more than 200 years at the recent rate of mining.

Because of the emphasis of Swedish producers upon high-quality products, relatively large tonnages of commercial grades must be imported to meet local needs. In some years as much as 50 per cent of the tonnage of steel produced in Sweden has been exported, while almost as great a tonnage, although of different grades of products, has been imported.

Radio-Telephony

ACCORDING to *QST*, January, 1946, a new development in radio-telephony was demonstrated by the Federal Telecommunication Laboratories. The development, known as pulse time modulation, produces a system whereby twenty-four or more conversations can be carried on the same radio frequency simultaneously without interference with each other.

The PTM demonstration was conducted from the International Telephone and Telegraph Corporation building in New York, N. Y., from which the PTM transmissions were beamed to a repeater station at Telegraph Hill, northwest of Red Bank, N. J. From there the signals were beamed to a second repeater station at the new Federal Laboratories at Nutley, N. J., and thence back to the top floor of the building in New York. Federal engineers stated the circuit could be 8,000 miles long, or more, and still maintain the same quality of transmission. Repeater stations are required at intervals of approximately 30 miles along the 1300-megacycle circuit.

The PTM system "chops" the conversation up into small bits and fits them back together again at the point of reception. The pulses are so rapid and the bits of conversation fitted so compactly in time intervals that when they are filtered at the receiving end and each conversation is reintegrated, the human ear is incapable of detecting the process. A faithful reproduction of each of the twenty-four speakers' voices is produced, each one being selected automatically for the receiving station individually called. The key to the filtering process is the Cyclophon tube, developed by the Federal Telecommunication Laboratories. The audible results which PTM presents to the ear are comparable with visual effects which the motion picture presents to the eye. Although the screen in a motion-picture theater is completely dark much of the time that a film is being shown, the eye is not quick enough to detect the dark intervals. The effect of PTM on the ear is reported to be as flawless as the effect presented to the eye by the modern movie.

Foreign Industrialization

WHILE the United States is currently engaged in the problems of reconversion, many countries abroad are concentrating their attention on the problems of industrialization.

Paralleling her effort directed toward reconverting displaced industry, the Soviet Union is laying the groundwork for a new five-year plan covering the years 1946 to 1950. In an article, "Russia Expands," by Weldon B. Hill (*The Oil Weekly*, November, 1945) Russian progress in the development of oil and natural-gas resources is described. Upon a foundation of vast petroleum reserves, the Soviet Union envisions the creation of a mighty industrial empire.

The Soviet Union has discovered vast petroleum fields east of Moscow on both the east and west sides of the Ural Mountains. Of the seven definitely known new fields in the Bashkiria region east of Moscow on the west side of the Urals, the largest in proved acreage is that at Buguruslan of 12,000 acres. The most important producing field, however, is at Kinzebulatova, near Ishimbai, which was opened in 1943 and is now producing about 30,000 bbl per day. This one field is estimated to be producing a third of the current output of the Bashkiria region.

In 1941 Russian leaders prohibited the opening of new oil fields unless adequate provisions were first completed for the recovery of natural gas released. This restriction, coupled with the extensive program of natural-gas pipe lines and gathering systems to provide big steel and manufacturing centers started during the German invasion, may place the Soviet Union well ahead of the United States in the full utilization of natural gas. A 400-mile pipe line is reported to have been completed to supply Sverdlovsk, "the Pittsburgh of Russia," which is east of the Urals, with gas from the new and important oil field at Cherdin, which is west of the Urals.

Although the most aggressive crude-oil production program in Russian history is under way, the Soviet government is embarking on a plan to produce synthetic oil. No information is available concerning the raw materials or the process to be utilized, but it is known that two synthetic fuel plants are now in construction.

MEXICO

Similarly, in Mexico, where the oil industry is a state monopoly managed by the Petroleos Mexicanos, oil and natural-gas facilities are being developed as the keystone of national industrialization. In several articles under the general heading, "Mexico Looks Ahead" (*The Oil Weekly*, November, 1945), L. J. Logan explains the detailed organization of the Petroleos Mexicanos, how this organization is currently expanding refining and distribution facilities, and how plans are being laid for a vigorous exploration program.

Petroleos Mexicanos, or "Pemex," is ultimately controlled by the President of Mexico, whose appointees have the determining voice in its management. As in private companies, determination of policy is vested in a board of directors, five of whom are appointed by the president and four by the labor syndicate. While the four labor members are outnumbered by the presidential appointees, they nevertheless wield strong power.

Like companies in the United States, Pemex serves also as collector of the taxes on gasoline and other products. Early in 1945 the government became emphatically insistent that Pemex must "stand on its own feet," and the company is making an earnest effort to do so.

As official trustee of Mexico's petroleum resources, Pemex foresees and is planning a future in which the nation's consumption of oils will show a healthy increase and in which the requirements will continue to be fulfilled by the country's re-

sources. Pemex has the double responsibility of encouraging and stimulating consumption on one hand and of being able to fulfill the demand on the other.

In line with the expansion of refining and distribution, work was started in September, 1945, on a refinery at Salamanca approximately 150 miles from Mexico City.

President Manuel Avila Camacho laid the cornerstone and Efrain Buenrostro, general manager of Pemex, described the project as part of a "ten-year plan" of oil-industry development. The refinery will supply the adjacent important industrial and mining region.

The company is employing currently 28 geological and geophysical parties, which is said to represent more exploratory work than was ever carried on at any time by all the private companies combined. In 1946 the total number of parties will be increased to 36.

While Petroleos Mexicanos is largely the Mexican oil industry within itself, there are limited private holdings including, especially, those of Gulf Oil Corporation, whose properties were not expropriated. Other American companies have settled with the Mexican government, but the British controlled Aguila Company (Shell), the largest owner of oil properties before the expropriation in 1938, still maintains its claims and no settlement appears near.

BRAZIL

A comprehensive survey of the current and potential industrialization of Brazil is reported by Rolt Hammond in an article, "An Engineer Looks at Brazil," continued through the four July, 1945, issues of *The Engineer*.

While much of Brazilian economy revolves about one agricultural product, coffee, the country is rich in iron ore and hydraulic power that promise the development of many industries. Iron ore exists in every state of the country and in such abundance that it is estimated that Brazil alone can supply the world's needs for a hundred years. The deposits of Itabira constitute a veritable mountain of hematite with few impurities, making it comparatively easy to reduce. Some deposits extend for miles and are as much as a mile in width. Much of the ore contains from 55 to 65 per cent of iron, or about 10 per cent more than the Great Lakes ores of the United States. Until recently no steel industry of any size was in operation in Brazil because it was believed that the local coals which are very high in ash and sulphur content could not be utilized. Subsequent research by the Battelle Memorial Institute of Columbus, Ohio, overcame the Brazil coal problem, and today a new steel mill at Volta Redonda, 90 miles from Rio de Janeiro, financed by the Export Bank of the United States and Brazilian interests, is in operation and is expected to achieve an annual output of 300,000 tons of steel and 50,000 tons of pig iron.

Brazil is fortunate in having exceptional hydroelectric power resources. In the general vicinity of Rio de Janeiro there is a geological feature known as the Serra do Mar, a plateau lying about 2500 ft above sea level. The plateau is a region of heavy rainfall and is served by several rivers. The rivers, instead of flowing toward the sea over the edge of the plateau, flow inland where the grade averages only 1 to 3000. In recent years the hydroelectric power resources of this region have been exploited by damming the rivers to form reservoirs which lead the water to the edge of the plateau from which it is dropped in pipes to the power station. The first large reservoir provides flow adequate for the generation of 246,000 hp. Waters from a secondary reservoir are pumped 25 to 85 ft to the main reservoir to provide an additional 140,000 hp. Additional power up to a maximum of 550,000 hp can be developed by pumping the flow of one of the rivers up a rectified channel into the main reservoir. It has been estimated that the Serra do Mar can provide adequate water for generating 10,000 hp for each mile of ocean front along the plateau.

CHINA

In China the word "industrialization" has taken on a deep and significant meaning. It signifies not only the reconstruction of the national life, but a change on a grand scale from age-old methods of production, as well as an alteration in the Chinese ways of living.

Chen Yun, in a speech, "China's Postwar Industrialization" (*Beama Journal*, October, 1945), said: "It is no exaggeration to say that industrialization has become a national movement in China. China fully realizes that without industrialization the standard of living, or we may say the purchasing power of her four hundred million people, can hardly be raised; without industrialization she can hardly be a stabilizing factor in world peace and world prosperity. She realizes that if her eight years of war against the invader are not to be followed by a full-swing program of industrialization, the blood of millions of her people will have been shed in vain.

"China is an economically backward country. In order to carry out any sizeable reconstruction program, we need foreign assistance, financial, technical, managerial, and even moral. Just as we needed the close co-operation of the Allied Powers to win a war against the Japanese invader, so we need your collaboration and assistance to win a war against our internal economic handicaps and backwardness.

"I cannot overemphasize the fact that the most immediate objective of our modest industrialization program is to raise the standard of living and the purchasing power of the common people in China. Chinese cheap labor must no longer be exploited by our foreign friends, nor by our own nationals. The worker must have decent living conditions and reasonable wages. As soon as he can buy more and enjoy life more, the peace of the Far East, and ultimately, of the world, is secured."

Hydraulic Drive

THE Brad Foote Gear Works, Inc., Cicero 50, Ill., has announced a Speed-Flo drive, consisting of a clutch and speed control for machine tools, maritime hoists, bus and truck tractors, and utility drives. The unit is totally enclosed—its compact housing allowing for practical and easy installation on any unit between the driver and driven member, and as it does not generate excessive heat due to its hydrostatic principle which balances the demand load without friction, it is not necessary to employ any open portings for cooling or other devices to maintain its normal thermal rating.

Another important advantage is said to be in the immediate cushioning of tremendous shocks transmitted throughout the gear train to engines of extremely high horsepowers. These shocks are prevented by the hydrostatic pressure built up in the gear pump assembly, the shock being taken up by the fluid, and the maintenance of a pressure within the safe working stresses of the parts of the vehicle is assured.

The power unit consists of four planetary gears and a sun gear, the sun gear being directly attached to the output shaft. Each planet gear in combination with the sun gear forms a hydraulic pump. The reservoir contains the oil, the valve seat, the valve, and air. The rotation of the engine causes the rotation of the clutch housing. Inasmuch as the idling speed of the engine is above 300 rpm, the oil forms an annulus in the reservoir with the air in the center of the reservoir. When the clutch is disengaged the valve is so constructed as to baffle the oil, and the planet gears rotating about the sun gear pump air

from the center of the reservoir and discharge this air back into the center of the reservoir. When starting to engage the clutch by an axial movement of the valve, both oil and air enter into the pumps. At the same time the valve movement starts to close off the discharge of the pumps thereby creating a hydro-

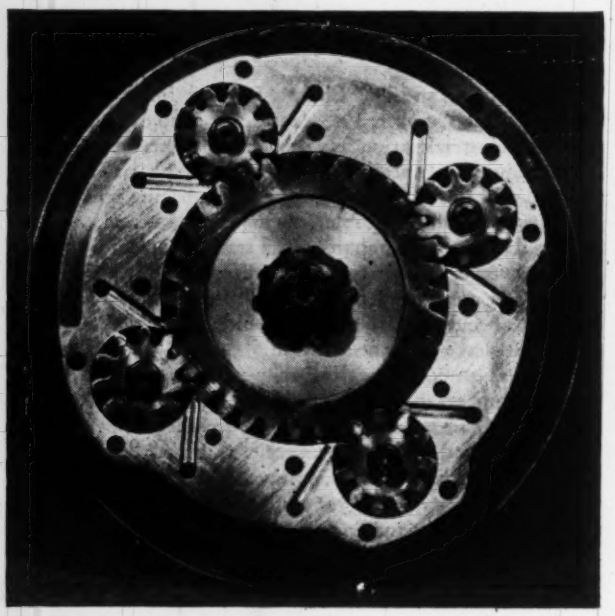

FIG. 11 SPEED-FLO DRIVE WITH SIDE PLATE REMOVED SHOWING SUN GEAR IN MESH WITH PLANETARY GEARS

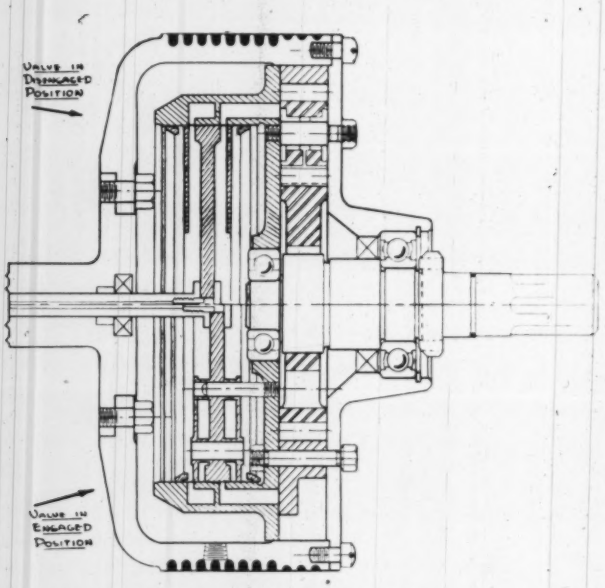

FIG. 12 SECTION THROUGH SPEED-FLO DRIVE SHOWING VALVE IN ENGAGED AND DISENGAGED POSITIONS

static pressure against the sun gear. As the clutch becomes fully engaged the valve allows free oil to enter the pumps, and the discharge port is completely closed, thereby creating maximum pressure against the sun gear. The clutch is designed to transmit maximum torque of the engine, therefore motion of the vehicle during engagement of the clutch is obtained. By employing a centrifugal governor to control the valve in the hydraulic clutch, a hydraulic speed control is attained.

Solar Energy

INDUSTRIAL utilization of solar energy will make an appearance shortly when a new type of solar converter begins supplying power to the Tashkent Cannery at Tashkent, Uzbek, in the U.S.S.R., according to an article in the January issue of *Power*.

Finishing touches are now being given to two experimental industrial converters of solar energy designed by the solar-energy group of the Power Institute of the U.S.S.R. Academy of Sciences. Dr. Federico Molero heads the group. Methods have been worked out for producing huge paraboloidal mirrors capable of achieving high concentrations of solar energy with installations not requiring any great degree of precision to manufacture. These units can produce steam at all temperatures and pressures required in industry.

In some branches of Central Asian economy the highest power requirements coincide with the sunny season of the year. This is true of agriculture where solar installations can pump water for irrigation systems, watering livestock, and refrigeration. Ice that can be produced with solar energy is needed most of all in the seasons that have a maximum of sunshine.

Sun installations that work parallel with ordinary steam equipment will also find extensive use at factories producing vegetable oils. These factories in Central Asia are located in remote areas where shipment of fuel involves big expense. With the local supply of waste products sufficient to cover their fuel requirements for half the year, solar energy will take care of the remaining half.

A mirror of 80-square meter surface has already been manufactured for the Central Asian machine.

Electrical Home Appliances

SPEAKING before metropolitan newspaper and magazine editors at a luncheon preview of 1946 Westinghouse consumer products at the Hotel Waldorf-Astoria, New York, N. Y., Jan. 30, 1946, B. W. Clark, vice-president in charge of sales for the Westinghouse Electric Corporation, predicted that the modern age of electrical living now dawning in American homes would provide jobs for more than 600,000 men and women and would mean an annual business of $4,500,000,000 during the next five years.

J. H. Ashbaugh, vice-president in charge of the electrical appliance division of the Westinghouse Company, pointed out that up to the time of the electrical strike, employment was only 400 below the prewar peak of 5500, yet production was 40 per cent below prewar output, due to the necessity of retraining employees, shortages of materials, and the general problems involved in reconversion.

Commenting on future appliance production schedules, Mr. Ashbaugh said that due to uncertainties caused by the strike, "it is my feeling that we will see summer come and go before appliances are available in any quantity."

On display at the preview were many electrical household products that will, when they become obtainable, make "better living and better homes" for housewives. Among the new aids displayed were the automatic cycle Laundromat, a washing machine that washes, rinses, and damp-dries in half an hour; upright home freezers; an electric roaster with an 18-quart capacity and featuring a "look-in" glass panel; and the home central unit Precipitron, an electrostatic air cleaner.

Most outstanding of the home radio sets on display was the DUO—a wood and plastic table phonograph-combination from which the radio can be removed as a complete unit and carried elsewhere to serve as a straight receiver.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Industrial Organization and Management

INDUSTRIAL ORGANIZATION AND MANAGEMENT. By Lawrence L. Bethel, Franklin S. Atwater, George H. E. Smith, and Harvey A. Stackman, Jr. McGraw-Hill Book Co., Inc., New York, N. Y., 1945. Cloth, $5^3/_4 \times 8^3/_4$ in., 798 pp., 169 figs., supp. plates, bibliography, $4.50.

REVIEWED BY J. M. JURAN[1]

AS a beginner's text in management, this book has been prepared to encompass unusual breadth of subject matter, and this in a highly readable style. These attributes place it in the front rank of the available texts.

In two respects there is a more than generous development of what is often treated hurriedly or not at all; (*a*) the background of American industry and (*b*) the relationship of Industry to all else. These two discussions provide, for the problem of industrial management, a most useful perspective in the dimensions of time and importance, respectively.

During the discussion of the usual various functions of industrial activity, the authors provide sustained interest through vivid diction. The chapter summaries are equally well prepared. In addition, the questions for class discussion are unusually well chosen from the standpoint of practical application and for stimulating discussion on controversial issues.

This excellent performance by the authors is mainly at the technique level. When it comes to broad principles, the book is sometimes wide of the mark or is too busy with techniques to expound principles. Thus the authors undertake (courageously, for such books) to discuss some of the problems of collective bargaining. Yet the very basis of collective bargaining—the principle of industrial government, with the consent of the governed—is not expounded. Again, there is discussion of seniority problems, yet the principle of rights in the job, which is the very basis of seniority, is not expounded. Similar instances of dwelling on techniques while by-passing premises are found in the discussions of "Free Enterprise" Vs. "Government Control." Moreover, in the discussions of this last issue there appears a definite bias in the text.

One of the shortest roads to frustration is a logical path from a false premise. True, many of the principles surrounding Industrial Management are highly debatable, and the debate on them is by no means concluded. Yet the textbook writer has the duty of stating the principles clearly. Where there is debate, he has the added duty of stating the arguments on *all* sides as forcefully as do the respective proponents. It is a self-contradiction for the textbook writer to be an advocate.

Omissions in vital subject matter are rare in this book. Discussion on research in management is absent. So is discussion of the fact that administration of the techniques is always in the hands of fallible men, whose errors of administration can nullify the best techniques.

But in the aggregate, the reviewer is hard put to locate specific points of criticism. Rather he must conclude that the book gives clear evidence of unusual determination by the authors to raise their text beyond the existing levels, and of exercise of great skill in the endeavor to carry out that intention. All this extends beyond the text material into the problems, for these are unusually well chosen and stated. It extends into the bibliography which is generous and well classified.

The growth of organizations, in size and in complexity, continues to demand better management and, in turn, better training in the industrial engineering curricula. The present book is clearly a step forward toward such training.

[1] Professor and Chairman, Department of Administrative Engineering, New York University, New York, N. Y. Mem. A.S.M.E.

American Labor Unions

AMERICAN LABOR UNIONS: WHAT THEY ARE AND HOW THEY WORK. By Florence Peterson. Harper and Brothers, New York, N. Y., 1945. Cloth, $5^1/_2 \times 8^1/_2$ in., 338 pp., $3.

REVIEWED BY MORRIS LLEWELLYN COOKE[2]

THIS book includes an astounding multiplicity of factual detail, the assembly of which might have been quite out of the question except for one associated with the Department of Labor. Despite all the listing and cataloging the author has made it readable especially for those outside the labor movement. There is practically nothing as to the machinery of labor organization which is not adequately covered. Perhaps too the author is warranted in claiming that the book describes "how labor unions, as organisms, perform their functions and conduct their daily affairs." Certainly no one wanting to be posted about unions can afford not to read and own it.

Because the discussions are based largely on the written word such as collective agreements and labor-union literature the author is led to say in her preface that "one would be a novice in human affairs to assume that any formally adopted policies and rules . . . . are an accurate portrayal of the groups' conduct at all times and under all circumstances." No such book can provide an understanding of a movement which had its inconspicuous start amid wild turbulence, has fought its way through 150 years of fierce opposition until, at present, with many of the accouterments of power it studies out its future in the confidence of ultimately achieving worth-while and inspiring goals. Miss Peterson has not diluted her valuable book with philosophical dissertations as to labor's past, its current strivings, or its ultimate objectives. But her first two chapters, giving a factual history of the American labor movement, are gems as to succinctness.

One of the most interesting exhibits bearing on organization is a table (p. 61) listing the international unions classified by size. It establishes by arithmetic a fundamental difference between A.F.of L. and C.I.O. With dues-paying membership in the two organizations somewhat comparable it shows that 84 per cent of the A.F.of L. membership is in unions with less than 100,000 members while C.I.O. has only 31 per cent of its members in unions of that size. Seemingly the

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fact that over 82 per cent of all union membership is in unions smaller than one hundred thousand is a very significant fact.

The chapters devoted to "The Labor Press," "Educational Activities," and "Co-operative Activities"—such as producer and consumer co-operatives, labor banking, and insurance—are thorough and throw light on very significant union attitudes. The labor press, over 500 individual publications, has gone forward by leaps and bounds since World War I. In some unions educational work is on a scale few outsiders realize. Personally, I cannot be too enthusiastic about this. If our public and private educational institutions—schools, colleges, and universities—would study the ways of meeting labor's unique educational needs, the necessity for labor's own educational activities, inevitably fostering class consciousness, would largely be done away with.

An interesting and enlightening feature of this book is a "Glossary of Labor Terms" including definitions of 260 such expressions. I am able to discover only two omissions, i.e., discipline and the sardine picket. Labor union discipline has always been recognized as an essential element in strong unionism. With the greatly expanded membership in recent years naturally discipline—especially in some unions—is at a considerably lower level than usual. This fact is a headache for employers and labor leaders alike. The discovery having been made that trucks carrying strike breakers will run into and then past standing pickets, the most modern type of picketing is done by lying down in concentric circles. It is alleged that no truck driver will run over a prostrate body.

There is little in this book to indicate that the American labor movement is growing up and growing up fast. I was familiar in a fashion with the manner in which the strike about 1919 in the steel industry was precipitated and conducted. It is a far cry from those "goings on" to the program of the steelworkers today in a somewhat comparable situation.

The Executive in Action

THE EXECUTIVE IN ACTION. By Marshall Edward Dimock. Harper & Brothers, New York, N. Y., 1945. Cloth, 5¼ × 8⅜ in., 276 pp., $3.

REVIEWED BY A. R. STEVENSON, JR.[3]

THE author treats this important subject in two ways which make an interesting combination. The book is full of general principles and they are illustrated by anecdotes from his experience as head of a large government bureau. He tries to indicate that the same principles apply in running a government bureau as in running a private business. In reading the book, I marked the paragraphs that interested me. I discovered that none of the marked paragraphs had to do with the particular examples which he had cited but all of them had to do with the fundamental principles which are scattered throughout the book. In other words, surprising as it might seem, his statements of general principles appear to be more interesting than the specific examples. Samples of the general principles are:

"Irrespective of the social institution with which one is connected, the common factor in all executive work is navigation—knowing where you want to go, what shoals you must avoid, what the forces are with which you must deal, and how to handle yourself, your ship, and your crew, effectively and without waste, in the process of getting there."

"Nothing is more important in the equipment of a successful administrator than physical vitality, and a constant flow of energy cannot be maintained unless he works according to a reasonable schedule and takes care of himself. There is an arithmetic about the expenditure of human energy. The man who works beyond the normal number of hours must expect a physical letdown during which his accomplishment will be reduced. If this period of overwork is continued, he may expect to pay for it later in the form of lowered reserve energy or even physical disability."

"The executive who analyzes his functions deliberately will find that he had three principal concerns, the importance of which occurs in the following order:

First, he must keep the enterprise on an even keel, by which I mean that he must constantly expect the unexpected and be ready to deal with crises whenever and wherever they appear. Second, he must delegate everything that he can to those working under and with him. Third, if the program is going along satisfactorily, he then has the time and nervous energy with which to chart the course that lies ahead, to survey new horizons, and to add to the effectiveness of existing equipment."

"A common difference between executives is that some, because of temperament and general make-up, are not content unless they are out front in everything that concerns their organization and, in consequence, they seldom give others a break. This is the extrovert who sometimes indulges in exhibitionism, in which case he is usually unpopular. In contrast is the person who prefers in most situations to run things by pulling strings, by putting others out in front, and by stepping into the breach only when necessary. The first type of executive gets results by exhortation and direct stimulus; the second secures his by tactics and delegation."

"When the executive has confidence in a man, he must be prepared to take a chance on his delivering to the extent anticipated. He must constantly assume that his subordinates are capable of performing above the level they have attained in the past."

"The test of a good staff official is whether he can tie in closely with the stream of operations so as to feel that his work is a part of it, and at the same time keep his perspective, objectivity, and capacity to reflect the plan. This is a difficult feat, requiring balance and a good sense of strategy. It means a particular mixture of personal traits, usually involving an academic interest in research combined with the kind of personality that makes it possible to sell one's wares to the operating official who has need of them."

[3] General Electric Company, Schenectady, N. Y. Fellow A.S.M.E.

Principles of Industrial Process Control

PRINCIPLES OF INDUSTRIAL CONTROL. By Donald P. Eckman. John Wiley & Sons, Inc., New York, N. Y., 1945. Cloth, 5½ × 8⅜ in., 237 pp., illus., $3.50.

REVIEWED BY WINFIELD B. HEINZ[4]

IT was the author's intention, according to the preface of this book, to write for students of automatic control. Although the author recognizes that many industrial employees are students of automatic control, the book is directed principally toward the collegiate group. Yet certain inexactnesses and certain nonscientific usages suggest that the author tried at times to "write down" to the nontechnical part of his industrial public. His adoption of the term "lag coefficient" instead of the universally recognized "time constant" is regrettable, particularly since there is also represented by the same symbol (L) in the book, a "lag fac-

[4] Consulting Development Engineer, Bound Brook, N. J. Mem. A.S.M.E.

tor" which has an entirely different meaning.

This book can be distinctly useful to a wide audience, and in particular to three classified groups—college students, industrial beginners, and people who are experienced in the practice of automatic control, but who need to increase their familiarity with the simpler fundamental theory.

In chapters on "Characteristics of Measuring Means," "Modes of Automatic Control," "Process Characteristics," and "Theory of Automatic Control," the author presents fundamentals in mathematical language, but with such clear explanations that industrious readers with limited mathematical knowledge can (if they try) understand the significance of the equations and thus obtain a better grasp of the phenomena which they describe. Instrument engineers will also find useful the simplified presentation of the Ziegler-Nichols method for prescribing controller settings by analysis of process reaction curves.

Mr. Eckman presents in numerical and graphical form many typical time constants, response characteristics, and reaction curves for various measuring means, controllers, and processes which have come within the extensive experience of his company. The figures should be of interest to those numerous instrument engineers who are thoroughly familiar with such phenomena, but who have rarely measured them. The risk of error from careless use of his illustrative data, against which the author cautions his readers, would have been reduced had he specified the conditions of test more fully, and had he given a range of values in each case, instead of a single number.

A chapter on "Automatic Control Systems" collects for reference and comparison a number of useful combinations of control mechanisms. Flow ratio control is discussed here, as well as time cycle control and several useful and less well-known arrangements.

It is this reviewer's opinion that the book presents a well-balanced introduction to its stated field. In combination with basic studies in related sciences, and with the aid of selected references from lists which follow the individual chapters, it will enable any intelligent student to work effectively in industrial process control.

Diesel-Electric Plants

DIESEL-ELECTRIC PLANTS. By Edgar J. Kates. Second edition. American Technical Society, Chicago, Ill., 1945. Cloth, $5^1/_2 \times 8^1/_4$ in., 272 pp., 170 figs., $3.75.

REVIEWED BY F. G. HECHLER[5]

THE first edition of "Diesel Electric Plants," which appeared in 1936, was reprinted four times between 1939 and 1944. Although the tremendous growth of the Diesel industry during the war unquestionably increased the demand for this small volume, the successive reprintings bear testimony to its merit and indicate that it meets a real need. The author has taken advantage of the opportunity presented by the new edition thoroughly to revise the text where necessary and to add new material to bring it up to date by including important developments and improvements in electric equipment used with Diesel engines. These revisions have resulted in a volume of 272 pages compared to the first edition of 181 pages.

The first chapter deals in general terms with the characteristics of Diesel engines and the fields of application of Diesel-electric equipment, while the last chapter deals in a popular way with Diesel-electric locomotives. Intermediate chapters deal with various electrical components and explain clearly the use of alternating-current and direct-current generators for Diesel drive; voltage regulation; parallel operation; engine governors, including automatic control of frequency and load sharing; automatic operation; automatic controls and alarms; electric starting; and installation and maintenance of generators and voltage regulators.

These chapters should prove particularly valuable to the engineer who needs to familiarize himself with these subjects as well as to the executive who wants to make an intelligent decision regarding proposed plant equipment. The volume is well illustrated with carefully chosen representative equipment which is described in detail. The author wisely refrains from making specific recommendations or endorsing any particular device.

Although "Diesel-Electric Plants" cannot take the place of a competent consultant in insuring the best and most economical installation for a given job, it does furnish a wealth of useful information in a well-arranged form that should be helpful both to the novice and to the expert.

[5] Director, Engineering Experiment Station, The Pennsylvania State College, State College, Pa. Mem. A.S.M.E.

Books Received in Library

ACIERS À OUTILS. By A. Michel. Dunod, Paris, France, 1944. Paper, $6^1/_4 \times 9^1/_2$ in., 246 pp., illus., diagrams, charts, tables, 245 fr. This treatise on tool steels describes the different types, covering constitution, structure, properties, heat-treatment, etc. In addition to the steels and steel alloys whose principal constituent is iron, the book also deals briefly with stellite, the iron-cobalt-tungsten alloy (50 per cent iron), and the metal carbides. The final chapter discusses temperature measurement.

A.S.M. REVIEW OF METAL LITERATURE, Vol. 1, 1944, prepared by T. Reinberg. American Society for Metals, Cleveland, Ohio, 1945. Cloth, $6 \times 9^1/_4$ in., 699 pp., $15. This volume contains the annotated lists of books and articles published during the year 1944 that appeared serially in *The Metals Review*. The entries are classified carefully, and author and subject indexes are provided, affording three approaches to the literature. Appended is a bibliography of publications on quality evluation that appeared between 1925 and 1932. The book is a valuable addition to metallurgical reference books.

AERIAL NAVIGATION. By H. E. Benham. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1945. Cloth, $5^1/_2 \times 8^3/_4$ in., 344 pp., illus., diagrams, charts, tables, $4. Beginning with a description of the characteristics of the earth and the methods of depicting all or parts of it on charts or maps, this book proceeds to describe the underlying principles of the main methods of aerial navigation. The effective techniques for applying these fundamentals to practical navigation are explained in detail with a wealth of helpful illustrations. A brief glossary of terms and abbreviations is appended.

A.S.T.M. STANDARDS ON PLASTICS, sponsored by A.S.T.M. Committee D-20 on Plastics. Specifications, Methods of Testing, Nomenclature, Definitions. May, 1945. American Society for Testing Materials, Philadelphia, Pa. Paper, 6×9 in., 542 pp., illus., diagrams, charts, tables, $2.75. The third edition of this compilation contains more than 100 specifications and methods of testing of plastics. Twenty four of these standards apply to plastics in the electrical insulation field. Nomenclature and definitions of and relating to the plastics field are included and there are two standards covering thermometers.

ATOMIC ENERGY IN WAR AND PEACE. By G. G. Hawley and S. W. Leifson. Reinhold Publishing Corporation, New York, N. Y., 1945. Cloth, $5 \times 7^3/_4$ in., 211 pp., illus., diagrams, tables, $2.50. The first part of this book discusses atoms, neutrons, energy transformations, combustion, explosions, radioactivity, transmutation, nuclear fission, and other subjects of fundamental importance. The second part, based on the official report of the atomic-bomb project, gives the story of this tremendous job, the obstacles to be surmounted, and the means by which it was done. A concluding section discusses future military and industrial applications of atomic energy in the light of present knowledge.

AUTOMOTIVE CHASSIS (without power plant). By P. M. Heldt. P. M. Heldt, Nyack, N. Y., 1945. Cloth, $5^1/_4 \times 8^1/_2$ in., 583 pp., illus., diagrams, charts, tables, $6. This final volume of a series of four on automotive engineering deals with the various parts of the automotive chassis, with the exception of the power plant. It discusses the functions of these parts: Frames, springs, wheels, gears, brakes, etc.,

their theory, the materials of which they are made, and their design. Rules for the proportioning of parts are given, and a brief historical survey of developments is included in some cases. Production processes are not covered except in cases where special methods yield superior results.

CALCULUS FOR PRACTICAL ENGINEERS in a simple, quick engineering way. By A. Cibulka. Clarke & Courts, Houston, Texas, 1944. Second edition. Paper, 9 1/2 × 12 in., 100 pp., illus., diagrams, tables, $3. The basic equations and functions are given from algebra through trigonometry, analytic geometry, differential and integral calculus, to differential equations. The processes of differentiation and integration are described in simple, practical language, with applications to a number of actual and varied engineering problems.

ENGINEERING ALLOYS, Names, Properties, Uses. By N. E. Woldman and R. J. Metzler. Second edition. American Society for Metals, Cleveland, Ohio, 1945. Cloth, 6 × 9 1/4 in., 832 pp., tables, $10. Section 1 of this compilation is an alphabetical list of alloys with corresponding serial numbers. In the more than 400 pages of Section 2 are given the alloy trade name, composition, properties, uses, and key numbers designating the manufacturers. The alloys are here listed by serial number. Section 3 is an alphabetical subject index of special characteristics and typical uses. Section 4 is a directory of manufacturers with their addresses and a summary of the alloys produced by each. A key index to manufacturers lists them by the designating numbers as used in Section 2. A useful data appendix includes also a classification of corrosion- and heat-resistant alloys. Some 12,500 entries appear in Section 2 in the new edition as compared with 8200 in the first edition.

EVERYDAY PROBLEMS IN ECONOMICS. By M. Wood-Simons. American Technical Society, Chicago, Ill., 1945. Cloth, 5 1/2 × 8 1/2 in., 544 pp., illus., diagrams, charts, tables, $3.50. The opening chapter presents a historical background of our economic structure. Succeeding chapters discuss the production, distribution, and consumption of economic goods; markets and trading; mining and agriculture; capital and labor; profits and wages; money and banking; foreign exchange and tariffs. In general the material is presented from the viewpoint of consumption and the consumer. A twenty-page specialized dictionary of economic terms is appended.

FAMOUS NEW ENGLAND LIGHTHOUSES. By E. R. Snow. Yankee Publishing Co., Boston, Mass. Cloth, 5 3/4 × 9 1/4 in., 457 pp., illus., $3.75. First of a series on American lighthouses, this volume gives briefly the history of every primary and secondary lighthouse in the Boston or New England district. The light itself is described, the stories of famous disasters and remarkable rescues associated with each are told with full credit to the man or woman whose participation was in the line of duty, the lighthouse-keeper.

FATIGUE DES MÉTAUX. By R. Cazaud and L. Persoz, preface by A. Caquot. Second edition. Dunod, Paris, France, 1943. Paper, 6 1/2 × 10 in., 259 pp., illus., diagrams, charts, tables, 262 fr. This monograph analyzes the principal studies of the fatigue of metals and presents the results in form for use by engineers and metallurgists. The theories of fatigue in metals, methods of testing, fatigue limits, the factors that affect fatigue, and the resistance of welded and riveted joints are discussed. Bibliographies accompany the several chapters.

FUNDAMENTAL THEORY OF SERVOMECHANISMS. By L. A. MacColl. D. Van Nostrand Co., Inc., New York, N. Y., 1945. Cloth, 6 × 9 1/4 in., 130 pp., diagrams, charts, $2.25. The advance in the art of automatic control is essentially the development of the modern servomechanism in which a change of condition affects the mechanism which in turn changes the condition. This book is concerned mainly with the general theory which is applicable to all linear continuously operating servomechanisms, with emphasis on its identity with the theory of feedback amplifiers. Some particular servomechanisms are discussed briefly, but no serious attempt is made to deal with the details of practical design.

HANDBOOK OF NONFERROUS METALLURGY, Principles and Processes, prepared by a staff of specialists. D. M. Liddell, editor in chief. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1945. Cloth, 5 3/4 × 9 in., 656 pp., illus., diagrams, charts, tables, $6.50. Volume 1 of this comprehensive two-volume handbook deals mainly with general principles and processes. Separate chapters written by authorities in the field deal with those operations, apparatus, and methods fundamental to all branches of nonferrous metallurgy. Sample chapter headings are: crushing and grinding; classification; filtration; roasting and sintering; metallurgical fuels; refractories; power plant and accessories; and the electric furnace. There are also chapters on plant layout, materials of metallurgical construction, and applied electrochemistry.

HYDRODYNAMICS. By Sir H. Lamb. Sixth edition. Dover Publications, New York, N. Y. Cloth, 6 × 9 in., 738 pp., diagrams, tables, $4.95. This is a reprinting of the sixth edition of this standard work on the classical theories of the dynamics of liquids and gases. These important theories, which underlie many present-day practical applications, are dealt with thoroughly and with mathematical rigidity. Among the special topics considered are the motion of solids through a liquid, vortex motion, and tidal waves.

INTERNAL-COMBUSTION ENGINES, Theory and Design. By V. L. Maleev. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1945. Cloth, 5 1/2 × 8 1/2 in., 636 pp., illus., diagrams, charts, tables, $5. This second edition of a standard text gives the student a general foundation in the theory, design, and operation of internal-combustion engines. Five new chapters have been added: combustion in spark-ignition engines; combustion in compression-ignition engines; compression-ignition combustion chambers; supercharging; and gas turbines. An important feature of the book is the considerable amount of material dealing with design procedure.

LE CYCLE A DEUX TEMPS, étude cinématique et thermique. By J. Jalbert. Dunod, Paris, France, (VI), 1944. Paper, 5 1/2 × 8 1/2 in., 134 pp., illus., diagrams, charts, tables, 72 fr. This interesting little work discusses the two-stroke cycle from the thermodynamic points of view. The author first studies the possible methods of charging, independently of their mechanical possibilities, and points out the thermodynamic results with each. He then studies ways in which each method of charging might be accomplished and the resulting advantages and disadvantages with respect to power, cost of manufacture and operation, and the field in which each method promises success. Finally, the characteristics of two-cycle engines are studied from the kinematic point of view.

MACHINE TOOL GUIDE Engineering Data, covering the principal machine tools, especially prepared for tool engineers, millwrights, and tool-equipment salesmen. American Technical Society, Chicago, Ill., 1945. Cloth, 8 × 11 in., 702 pp., illus., diagrams, charts, tables, $7.50. This work brings together in a single volume data hitherto available only in the catalogs and service manuals of individual machine-tool manufacturers. Drawings, specifications, dimensions, speeds, feeds, and other information provided by sixty-one leading manufacturers are given for the automatics, boring machines, drilling machines, lathes, milling machines, etc., made by these firms. The material is classified for convenient reference.

MACHINISTS' AND DRAFTSMEN'S HANDBOOK. By A. M. Wagener and H. R. Arthur. D. Van Nostrand Co., Inc., New York, N. Y., 1945. Fabricoid, 5 1/4 × 8 in., 662 pp., illus., diagrams, charts, tables, $4.50. The beginning chapters of this reference work deal chiefly with geometrical and trigonometrical constructions and calculations. Basic information on drills, threads, spur gearing, milling, speeds and feeds, and cutting tools is next presented. A considerable amount of tabulated information on the composition and heat-treatment of important metals and alloys is followed by substantial chapters discussing mechanics, logarithms, and the strength of materials. Tables of weights and measures are included.

MARINE ENGINEERS' HANDBOOK, prepared by a staff of specialists. J. M. Labberton, editor in chief, with the general engineering fundamentals reproduced from "Mechanical Engineers' Handbook" (L. S. Marks, editor in chief). McGraw-Hill Book Co., Inc., New York, N. Y., 1945. Fabricoid, 4 3/4 × 7 1/4 in. 2013 pp., illus., diagrams, charts, tables, $7.50. Designed as the successor to Sterling's "Marine Engineers' Handbook," this new compilation is intended especially for the use of design engineers and technical students. Operating engineers should find the design and construction details useful, but no attempt has been made to include instruction on the adjustment and maintenance of marine propulsion machinery. The section on reciprocating steam engines is virtually the same as in the older work, but all other sections are completely new or extensively revised. Many technical data of value to the marine engineer have been reprinted from Marks's "Mechanical Engineers' Handbook."

PIPING HANDBOOK. By S. Crocker. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1945. Cloth, 4 1/2 × 7 1/4 in., 1376 pp., illus., diagrams, charts, tables, $7. This standard work makes available under one cover a compilation of data for the effective design and use of piping in all its engineering and industrial applications, from water distribution to hydraulic systems for airplanes. The book authoritatively covers scientific fundamentals, materials, design, and installation practice, and many useful construction details. Cost analyses, standards, definitions, and references to additional sources are also included. Separate chapters are devoted to closely allied topics such as pumps and corrosion.

PLASTICS. By J. H. DuBois. American Technical Society, Chicago, Ill., 1945. Cloth, 5 1/2 × 8 1/2 in., 447 pp., illus., diagrams, charts, tables, $4. That this book, first published in 1942, has now reached its third edition, is an indication of the rapid advances in its field. It affords a simple, clear explanation of the manufacture of the more important plastics, discusses the manufacturing problems

of each, and their principal applications. The book is intended primarily for users of plastics.

PRACTICAL MANAGEMENT RESEARCH. By A. R. Wiren and C. Heyel. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1945. Cloth, $5^3/_4 \times 9$ in., 222 pp., charts, tables, $2.50. This book discusses the use of scientific research techniques in business, giving in detail the theory, principles, and methods for research into management problems. It describes the analysis of business problems and methods for conducting practical management and time studies. Part 2 presents case examples of the systematic solution of management problems selected from actual business experience.

PRACTICAL DESIGN HANDBOOK FOR ENGINEERS. By A. Cibulka. Clarke & Courts, Houston, Texas, 1945. New enlarged edition. Paper, 9×12 in., paged in sections, diagrams, charts, tables, $6. The earlier edition of this compilation of design data and formulas covered the following: strength of materials, steel and concrete structures; pressure and vacuum vessels, piping and metals; hydraulics and heat transfer; mathematical tables and general engineering formulas. The book now includes the formerly separate publications on aerial cable tramways, refinery piping, and modern welded steel structures "RST." Material has also been added on Vierendeel bridges, television towers, hangars, prestressed concrete tanks, hydraulic dams, and the construction of monographs. Most of the material is in the form of tables and charts, with such explanation as is considered necessary.

PRINCIPLES OF INDUSTRIAL PROCESS CONTROL. By D. P. Eckman. John Wiley & Sons., Inc., New York, N. Y.; Chapman & Hall, London, England, 1945. Cloth, $5^1/_4 \times 8^1/_2$ in., 237 pp., diagrams, charts, tables, $3.50. The purpose of this book is to treat, in a logical manner, the important laws of operation of industrial automatic control systems and to provide a practical background of theory. It presents a comprehensive treatment of measuring characteristics of controllers, controller characteristics, the effect of process load changes, the effect of valve characteristics, and correlated or multiple control systems. The principles that apply to the operation of a process when under automatic control are emphasized.

PRODUCTION ILLUSTRATION, the Techniques and Applications of Perspective Engineering Drawings. By J. Treacy. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1945. Cloth, $9^1/_4 \times 11^1/_2$ in., 202 pp., illus., diagrams, charts, tables, $4. Perspective drawing found wide adoption during the war as a medium for presenting engineering facts, especially to inexperienced workers unfamiliar with blueprints. This book presents the forms and processes of production illustration in simple form. Part one deals with the actual preparation of production illustrations, including drafting and shading techniques, short-cuts, perspective methods and aids to reproduction. Part two shows why, when, and where production illustration is of use in industrial production. The book is profusely illustrated with examples of actual production drawings.

RIGHTS OF TRAINS, a Complete Analysis of Single Track Standard Code Rules. By the late H. W. Forman, revised by P. Josserand. Third edition. Simmons-Boardman Publishing Corporation, New York, N. Y., and London, England, 1945. Cloth, $4^3/_4 \times 7^1/_2$ in., 561 pp., diagrams, charts, tables, $3.50. This manual analyzes the Standard Code of Operating Rules of the Association of American Railroads as applied to single and double track. It completely explains and illustrates train rules, train orders, and transportation problems of the operating department of any American railroad. Reasons for the rules are given, and questions and answers likely to be met in rules examinations are included to test the reader's understanding of the applications of the rules.

ROLL NECK BEARINGS. Part I, Design, Construction, and Operation. By L. R. Underwood. Iron and Steel Industrial Research Council, London, England, 1943. Cloth, $6 \times 9^3/_4$ in., 220 pp., illus., diagrams, charts, tables, 10s 6d. This report, which was prepared for the Rolling Mill Research Subcommittee and is published with the approval of the Iron and Steel Industrial Research Council of Great Britain, embodies the results of a study of the literature, of discussions with manufacturers of various types of roll-neck bearings, and with some experiences of users. The types of bearings in use are surveyed, and the economic and technical factors that govern the selection for a given application are reviewed. The theory of lubrication as applied to these bearings and bearing metals are considered. Later chapters deal with the design, construction, installation, and operation of plain, synthetic resin, fluid film, roller and needle bearings. A useful bibliography is included.

SCIENTIFIC SOCIETIES IN THE UNITED STATES. By R. S. Bates. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1945. Cloth, $5^1/_2 \times 8^3/_4$ in., 246 pp., tables, $3.50. The history and the influence of the scientific societies of the United States are the themes dealt with in this book. Beginning with the first small, short-lived organizations prior to the American Revolution, the author traces the development of this grouping together for scientific advancement down to the present-day multitude of national, state, and local societies. These developments are effectively related to other aspects of the growth of the United States. A thirty-page bibliography provides further material on all phases of the subject.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, Proceedings, Vol. 3, No. 1, edited by C. Lipson and W. M. Murray; published and distributed by Addison-Wesley Press, Kendall Square, Cambridge, Mass., 1945. Cloth, $8^1/_2 \times 11^1/_4$ in., 154 pp., illus., diagrams, charts, tables, $5. Twelve articles are included in the current volume, dealing with strain gages, residual stresses, stress models, analysis of shafting and of rivet shear tests, stress analysis with brittle coatings, and stresses in aircraft components. The contents pages of the previous volumes are included at the back. The illustrations in all the volumes are a particularly good feature of the publication.

SPUN RAYON WARP SIZING, Special Summary Report on Weaving Efficiency of Warp Sizing Materials, a research project of the Textile Research Institute, conducted at the North Carolina State College School of Textiles and the Research Laboratories of the Textile Foundation at the National Bureau of Standards, Washington, D. C.; issued by the Textile Research Institute, Inc., New York, N. Y., May 1, 1945. Paper, $8 \times 10^1/_2$ in., 91 pp., illus., diagrams, charts, tables, $1.50. Part 1 of this research report is designed to throw light on certain problems peculiar to the sizing of staple rayon warp yarns, including possible laboratory test methods. Part 2 deals with the weaving, efficiency, and film properties of warp sizing materials.

STRENGTH OF MATERIALS. By A. P. Poorman. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1945. Cloth, $5^1/_4 \times 8^1/_2$ in., 339 pp., illus., diagrams, charts, tables, $3. This standard textbook is intended for use in undergraduate courses in mechanics, and a knowledge of the principles of physics, the calculus, and statics is assumed. The first two chapters cover the general topics of stresses and strains in tension, compression, and shear. The rest of the book deals with shear and moment in beams, stresses and deflections in beams, columns, riveted and welded joints, and resilience in bars and springs. Material on aluminum, duralumin, and magnesium columns has been added in the new edition, with new problems throughout.

TABLES OF ASSOCIATED LEGENDRE FUNCTIONS, prepared by the Mathematical Tables Project, conducted under the sponsorship of the National Bureau of Standards, L. J. Briggs, Director, and A. N. Lowan, Project Director. Columbia University Press, New York, N. Y., 1945. Cloth, $7^1/_4 \times 11$ in., pp. xlvl + 306, tables, $5. Legendre functions are encountered in the general solution of the differential equations of wave motion and the potential theory in spherical co-ordinates. The present volume of a series of mathematical tables was produced to meet needs for a table of Legendre functions to about six significant figures at intervals of 0.1. Further work is to be done to improve the process of interpolation of these functions.

TECHNOLOGY OF PLASTICS AND RESINS. By J. P. Mason and J. F. Manning. D. Van Nostrand Co., Inc., New York, N. Y., 1945. Cloth, $6 \times 9^1/_4$ in., 493 pp., illus., diagrams, charts, tables, $6.50. The first section of this comprehensive work discusses the resinous and plastic states, the types and mechanisms of polymerization, and the relationship between various physical properties and the structure of plastics and resins. In the second section, the methods of preparation and the properties and uses of the more important resins and plastics are discussed, including two natural products, rubber and cellulose. The third section describes fabrication techniques: compounding and mold designs, molding, casting, laminating, and coating procedures.

Translation KEY TO KLEINLOGEL'S RAHMENFORMELN. By F. S. Morgenroth. Frederick Ungar Publishing Co., New York, N. Y., 1945. Cloth, $6 \times 9^1/_4$ in., 49 pp., $1.25. Kleinlogel's collection of formulas provides the designer with ready-to-use formulas for all the static stresses in frames. It has gone through eight editions in Germany and has been republished in this country. The present book will facilitate its use by engineers whose knowledge of German is slight, as it supplies translations of the important parts of the text.

VAPOR ADSORPTION, Industrial Applications and Competing Processes. By E. Ledoux, with foreword by D. F. Othmer. Chemical Publishing Co., Brooklyn, N. Y., 1945. Cloth, $5^1/_2 \times 8^3/_4$ in., 360 pp., illus., diagrams, charts, tables, $8.50. This story of adsorption, the concentration or retention of molecules on surfaces, is divided into four parts. In Part 1 the theories and calculations of static adsorption are discussed. Part 2 examines the thermal changes which occur when a vapor is added to air, particularly to the saturation point. Part 3 covers dynamic adsorption, with a current of air, for example, acting as a carrier for the vapor. The industrial applications of adsorption described in Part 4 deal mainly with various aspects of air conditioning and drying processes and with solvent recovery.

A.S.M.E. BOILER CODE

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph number to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added word are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., that they may be presented to the Committee for consideration.

FOREWORD. Revise the first sentence of the sixth paragraph of the Foreword to read:

Each state and municipality IN THE UNITED STATES AND EACH PROVINCE IN THE DOMINION OF CANADA that ADOPTS OR ACCEPTS [has accepted] one or more sections of the Boiler Code, etc.

Revise the first sentence of the seventh paragraph to read:

The National Board of Boiler and Pressure Vessel Inspectors is composed of chief inspectors of states and municipalities IN THE UNITED STATES AND OF PROVINCES IN THE DOMINION OF CANADA that have adopted the Boiler Code.

PAR. P-299 (a) Revise third section to read:

All valves and fittings shall be marked with the name, trade-mark, or other identification of the manufacturer and the primary service pressure rating EXCEPT THAT THE PRESSURE RATING MARKING MAY BE OMITTED FROM:

(1) CAST-IRON AND MALLEABLE IRON SCREWED FITTINGS FOR 150 LB WORKING PRESSURE;

(2) NONFERROUS SCREWED FITTINGS FOR 125 AND 250 LB WORKING PRESSURE;

(3) CAST-IRON AND NONFERROUS COMPANION FLANGES;

(4) BUTT-WELDING FITTINGS.

Additional markings as called for BY the SEVERAL CODE [American] Standards FOR ALL VALVES AND FITTINGS are recommended if the size and shape of the valve or fitting permit.

FIG. U-1. Revised form shown in the accompanying illustration.

PAR. U-59(o) (1). Revise by the addition of the word "or" at the end of (1).

PAR. U-71. Include a reference to Case No. 989 in the footnote to Par. U-71.

PAR. U-76(b). Revise to read:

(b) Unless otherwise limited by the provisions of Par. U-13(c), vessels constructed in accordance with Par. U-69 shall be stress-relieved where the thickness OF THE SHELL AT THE MAIN SEAMS exceeds $1^1/_4$ in., or where the diameter is less than that determined by the formula $d = 120t - 50$, where d is the inside diameter in inches, and t the shell thickness in inches. Vessels having a wall thickness less than 0.58 in. need not be stress-relieved regardless of diameter.

SINGLE PIECE HEADS OF PAR. U-69 VESSELS NEED NOT BE STRESS-RELIEVED IF JOINED TO SHELLS NOT REQUIRING STRESS-RELIEF.

HEADS, MADE OF MORE THAN ONE PIECE, OF PAR. U-69 VESSELS SHALL BE STRESS-RELIEVED WHEN OVER $1^1/_4$ IN. THICK AND, REGARDLESS OF THICKNESS, WHEN THEY ARE JOINED TO SHELLS REQUIRING STRESS-RELIEF.

PAR. U-208(e). Replace proposed revision of (1) and (3) appearing in February MECHANICAL ENGINEERING by the following:

(e) Retests. (1) SPOT EXAMINATION. When a spot has been examined and the welding does not comply with the minimum quality requirements referred to in (b) for radiographing or in (c) for sectioning, additional spots shall be examined by either method in every seam not previously examined on which the same operator has welded, to the number and at locations as shall be determined by the inspector. ALL ADDITIONAL SPECIMENS REMOVED BY SECTIONING SHALL COMPLY WITH THE MINIMUM QUALITY REQUIREMENTS OF (c), WHILE ALL ADDITIONAL SPOT RADIOGRAPHS SHALL COMPLY AT LEAST WITH THE STANDARD OF QUALITY DEFINED IN (2). Based on such examinations the inspector shall decide on the extent of local repairs or the need for the rewelding of all seams on which that operator has welded. Sectioning specimens meeting minimum quality requirements may be replaced by weld metal if, in the inspector's opinion, they are not so closely spaced that excessive residual stresses may result; otherwise the affected length of seam shall be completely rewelded. All rewelded areas shall be re-examined as required by the inspector and shall comply with the minimum quality requirements.

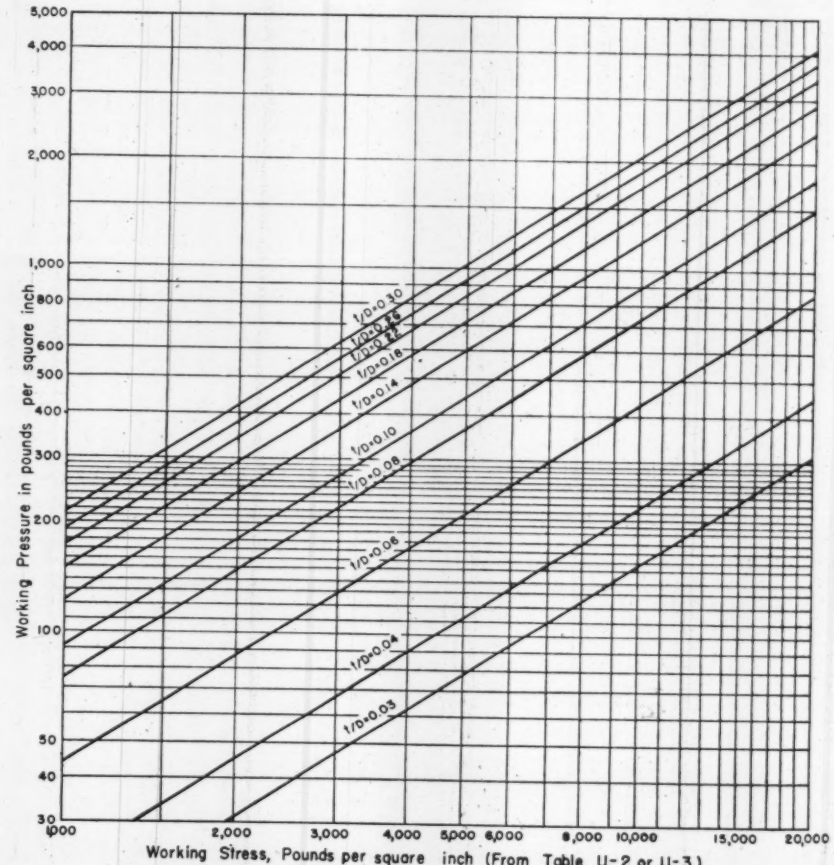


Fig. U-1 Chart for Determining Wall Thickness of Tubes under external pressure

A.S.M.E. NEWS

And Notes on Other Engineering Societies

A.S.M.E. 1946 Spring Meeting to Be Held in Chattanooga, Tenn., April 1 to 3

Stresses Hospitality and Industry of South

Twelve Technical Sessions—Thirty Diversified Papers

NOT since 1923 has Chattanooga, Tenn., had the opportunity of extending the hand of welcome and playing the host to The American Society of Mechanical Engineers. The East Tennessee Section is now once again preparing energetically for the A.S.M.E. 1946 Spring Meeting which is to be held in their industrial metropolis with headquarters at the Read House, April 1 to 3, 1946. During the intervening years not only has the Society grown in stature but the South has matured to a region of great cities teeming with diversified industry. Among these, Chattanooga stands well in the forefront, the geographical center of the Tennessee Valley Authority, the "Dynamo of Dixie."

A well-balanced program has been set up under the guiding hand of Roscoe W. Morton, professor of mechanical engineering, University of Tennessee, and a committee composed of prominent members of the East Tennessee Section and Chattanooga. There will be three luncheons and one banquet to convince members of the delights of Southern cooking; three inspection trips to show them the industrial activities of Chattanooga; and four groups of three simultaneous technical sessions each, to call attention to the wide range of engineering interests represented by A.S.M.E. Region IV.

Luncheons

The Chattanooga Engineers' Club will join in the luncheon on Monday, April 1, where Dr. Irvine W. Grote, Chattanooga Medicine Company, will speak on "Side Lights on Penicillin and Related Substances." At the Tuesday, April 2, luncheon, members will hear J. Parker Van Zandt, director, aviation research, Brookings Institution, Washington, D. C., speak on "Air Transportation and World Understanding." The last luncheon, on Wednesday, April 3, will have John P. Ferris, director, commerce department, Tennessee Valley Authority, Knoxville, Tenn., as speaker. His subject will be "Industrial Development in the Southeast."

Banquet

The social high light of the Spring Meeting will be the banquet. D. Robert Yarnall, president, A.S.M.E., and president, Yarnall-Waring Company, Philadelphia, Pa., will speak on "Engineering and Citizenship." E. E. Williams, vice-president A.S.M.E., Region IV, general superintendent, Duke Power Company, Charlotte, N. C., will be toastmaster, and L. G. Haller, Tennessee Eastman Corporation, Kingsport, Tenn., will welcome members on behalf of the East Tennessee Section.

Inspection Trips

The inspection trips have been so arranged that members will be able to enjoy these instructive interludes without sacrificing attendance at technical sessions. On Monday morning a party will set out to inspect the Chickamauga Dam and power plant of the T.V.A. The following morning members will have an opportunity to inspect the Combustion Engineering Company plant in Chattanooga, Tenn. On Wednesday afternoon two trips are scheduled: The first to the Ross Meehan Foundries and the Chattanooga Glass Works; the second to the Samuel Stamping and Enameling Plant and the American Lava Company.

Technical Sessions

Thirty papers will be presented by ten divisions. The sessions have been divided into

DOWNTOWN VIEW OF CHATTANOOGA, TENN., WHERE EAST TENNESSEE SECTION WILL BE HOST TO A.S.M.E. SPRING MEETING

four groups; three divisions will participate simultaneously in each group. Monday will be the heavy day for these sessions. The afternoon will be devoted to hydraulics, process industries, and prime movers (Diesel). Monday evening there will be sessions on power, metals engineering, and aviation. On Tuesday the afternoon only will be given over to technical papers. These sessions will be devoted to railroads and metals engineering, management, and power and fuels papers. On Wednesday the morning only is reserved for the technical part of the program. The third metals-engineering session, the second process-industries session, and an education and training session will be held.

The complete program of the A.S.M.E. 1946 Spring Meeting is given in the following pages.

Women Especially Invited

Because of the scenic and historic interest of Chattanooga and vicinity the women are especially invited to participate in the Spring Meeting. A program for them has been arranged which includes shopping tours, visits to antique shops, sight-seeing trips to Chickamauga Lake and Dam, the world-famous McDade orchid gardens on Signal Mountain, and to Lookout Mountain with luncheon at the Fairyland Club, followed by games of bridge and bingo.

Hotel Accommodations

What is true of all large centers is true of Chattanooga—there is a limit to the accommodations afforded by the hotels. Although it is not anticipated that members will have difficulty in finding hotel accommodations, members are urged to arrange for travel and hotel reservations as soon as possible.

The following hotels are reserving rooms for the meeting: Read House, Patten Hotel, Ross Hotel, Park Hotel, Key Hotel, and Plaza Hotel. Rates are $2.20 to $5.50 for single rooms and $4.40 to $8.80 for double rooms. Where possible, members are urged to double up on their hotel reservations.

Members should place reservations directly with the hotels. The hotels will confirm all reservations. Should the hotel be unable to grant reservations, the hotel will notify the committee, the reservation will be placed at some other hotel, and the member will be notified of the change.

Make Travel and Hotel Reservations Early!

NEW YORK MONUMENT ATOP LOOKOUT MOUNTAIN IN POINT PARK CHATTANOOGA, TENN.

Tentative Program of A.S.M.E. 1946 Spring Meeting, Chattanooga, Tenn., April 1 to 3

Headquarters, Read House

MONDAY, APRIL 1

8:00 a.m.

Registration at Read House

9:00 a.m.

Inspection Trip—Chickamauga Dam and Power Plant, T.V.A.

NOTE: If transportation difficulties are solved, this inspection trip will be held in the afternoon and the technical sessions will be held in the morning.

10:00 a.m.

Council Meeting

12:00 noon

Luncheon—Joint with Chattanooga Engineers' Club, W. G. Davies, chairman. "Side Lights on Penicillin and Related Substances," by Dr. Irvine W. Grote, Chattanooga Medicine Company, Chattanooga, Tenn.

2:00 p.m.

Council Meeting

Hydraulics

The Design of Mechanical Auxiliaries for Tennessee Valley Authority Hydroelectric Plants, by H. J. Petersen, head mechanical engineer for Tennessee Valley Authority, Knoxville, Tenn.

A Better Method of Representing and Studying Water Turbine Performance, by Robert A. Sutherland, hydraulics engineer, Ebasco Services, Incorporated, New York, N. Y.

The Nantahala Turbine, by J. B. Growdon, Aluminum Company of America, Pittsburgh, Pa., R. V. Terry, and H. H. Gnuse, Jr.

Process Industries (I)

Vegetable Oils

Factors Affecting Pressing, by Arnold Glass, Arthur H. Morgan, and W. H. Baskerville, engineering experiment station, University of Tennessee, Knoxville, Tenn.

Pilot-Plant Studies on Solvent Extraction of Cottonseed, by N. Hunt Moore, superintendent, Delta Products Company, Wilson, Ark.

The Refining and Hydrogenation of Vegetable Oils, by W. T. Watkins, assistant superintendent, Lookout Oil & Refining Company, Chattanooga, Tenn.

Prime Movers

Maintenance of Diesel Locomotives Under Wartime Conditions in Europe, by Isham Mann, Byers Pipe Company, New Orleans, La.

Electrohydraulic Regulators for Diesel-Electric Drives, by M. A. Edwards, assistant engineer, general engineering and consulting laboratory, and C. B. Lewis, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y.

8:00 p.m.

Power (I)

Power at Oak Ridge, by L. Skog and H. C. Schroeder, Sargent and Lundy, Chicago, Ill.

Design of Modern High-Pressure Boilers, by Claude L. Huey, Babcock & Wilcox Company, Atlanta, Ga.

Symposium—Corrosion in Power-Plant Operation

Metals Engineering (I)

Developments in Metal Fabricating, by E. C. Chapman, Combustion Engineering Company, Inc., Chattanooga, Tenn.

The Metallurgy of Meehanite, by Paul H. Stuff, Ross Meehan Foundries, Chattanooga, Tenn.

Aviation

Private Flying

Personal Aircraft—Manufacturers' Viewpoint, by W. T. Piper, president, Piper Aircraft Corporation, Lock Haven, Pa.

Personal Aircraft and Their Effect on the Future, by John H. Geisse, assistant to Administrator for personal-flying development, Civil Aeronautics Administration, Washington, D. C.

Aviation in the New South, by George Haddaway, editor, *Southern Flight*, Dallas, Texas

Motion Pictures of Bell Helicopter

TUESDAY, APRIL 2

9:00 a.m.

Inspection Trip—Combustion Engineering Company, Inc., Chattanooga, Tenn.

12:00 noon

Luncheon—Air Transportation and World Understanding, by J. Parker Van Zandt, director, aviation research, Brookings Institution, Washington, D. C.

2:00 p.m.

Railroads and Metals Engineering (II)

The Welded Locomotive Boiler

Design and Construction, by James Partington, manager, engineering department, American Locomotive Company, New York, N. Y.

The Performance of the Welded Boiler on the Delaware and Hudson Railroad, by G. S. Edmonds, superintendent, motive power, Delaware & Hudson Railroad, Albany, N. Y.

Heat-Treatment of the Welded Locomotive Boiler, by A. J. Moses, vice-president and general manager, Hedges-Walsh-Weidner Division, Combustion Engineering Company, Inc., Chattanooga, Tenn.

Remarks on Developments in the Use and Prospective Use of Fusion-Welded Locomotive Boilers, by John M. Hall, director, Bureau of Locomotive Inspection, Interstate Commerce Commission, Washington, D. C.

Management

Job Evaluation and Merit Rating, by Eugene Benge, Eugene Benge Associates, Chicago, Ill., and A. L. Kress, Republic Aviation Corporation, Farmingdale, L. I., N. Y.

Unionization of Professional Workers, by I. Melville Stein, director of research, Leeds and Northrup Company, Philadelphia, Pa.

Management-Union Relations, by E. T. Cheyfitz, secretary, International Union of Mine, Mill, and Smelter Workers, Committee on Industrial Organization, Washington, D. C.

Fuels (I) and Power (II)

Smokeless Furnaces and Stoves, by Julian Robert Fellows, professor, mechanical engineering, University of Illinois, Urbana, Ill.

Testing and Rating of Space Heaters, by W. H. Baskerville, assistant director, engineering experiment station, University of Tennessee, Knoxville, Tenn.

6:30 p.m.

Banquet

Toastmaster: E. E. Williams, general superintendent, Duke Power Company, Charlotte, N. C.

Welcome by L. G. Haller, superintendent of engineering, Tennessee Eastman Corporation, Kingsport, Tenn.

Address on Engineering and Citizenship, by D. Robert Yarnall, president, A.S.M.E. and president, Yarnall-Waring Company, Philadelphia, Pa.

WEDNESDAY, APRIL 3

9:00 a.m.

Metals Engineering (III)

Folding in Tube Sinking, by G. Sachs, professor of physical metallurgy, Case School of Applied Science, Cleveland, Ohio, and William M. Baldwin, metallurgical engineer, Chase Brass and Copper Company, Cleveland, Ohio

Stress Analysis in Tube Sinking, by G. Sachs, professor of physical metallurgy, Case School of Applied Science, Cleveland, Ohio, and William M. Baldwin, metallurgical engineer, Chase Brass and Copper Company, Cleveland, Ohio

Process Industries (II)

A Continuous Process for Manufacture of Laminated Lumber, by R. Brooks Taylor, chief, regional products division, Tennessee Valley Authority, Knoxville, Tenn.

Vegetable and Fruit-Drying Development, by Clarence Birdseye, Gloucester, Mass.

Fruit and Vegetable Preserving, by F. C. Hamilton, Southland Preserving Company, Chattanooga, Tenn.

Education and Training

The Directions in Which Education Should Be Guided in Order to Prepare the Oncoming Generation for This New Branch of Engineering—Nuclear Physics, by Prof. W. G. Pollard, University of Tennessee, Knoxville, Tenn.

Postgraduate Industrial Training, by A. R. Stevenson, Jr., staff assistant to vice-president, General Electric Company, Schenectady, N. Y.

12:00 noon

Luncheon: Address, Industrial Development in the Southeast, by John P. Ferris, director, commerce department, Tennessee Valley Authority, Knoxville, Tenn.

2:00 p.m.

Inspection Trips

Trip 1
Ross Meehan Foundries
Chattanooga Glass Works (Bottles)

Trip 2
Samuel Stamping and Enameling Company
American Lava Company

THURSDAY, APRIL 4

9:00 a.m.

Society for Promotion of Engineering Education Meeting

Registration Fee for Non-Members at the 1946 Spring Meeting

There will be a registration fee of $2 for nonmembers attending the 1946 Spring Meeting. For nonmembers wishing to attend just one session (except evening sessions or meal meetings) the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests (male) may avoid this fee by writing to the Secretary of the Society before March 22 asking for a guest-attendance card for the Spring Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

Time-Study and Methods Conference—New York, N. Y., April 26–27, 1946

A TIME-study and methods conference sponsored jointly by the Society for the Advancement of Management and the Management Division of the A.S.M.E. will be held at Hotel Pennsylvania, New York, N. Y., Friday and Saturday, April 26–27, 1946.

The conference will be divided into four sessions during which 12 papers covering job evaluation, training of time-study personnel, incentive systems, and office methods will be presented.

Dr. Herbert Spencer, president, Bucknell University, will address the conference on "How to Avoid Mistakes in Time Study and Incentives Which Lead to Arbitration" during the luncheon, Friday, April 26, 1946.

Conference committee is under the chairmanship of J. E. Louden, S.A.M. J. M. Juran, member A.S.M.E., is serving as vice-chairman.

1946 Regional Administrative Committee Meetings

Group	*City*	*Place*	*Date*	*Presiding Officer*
I	Boston	Statler Hotel	Apr. 30–May 1	Alton C. Chick
II	New York	A.S.M.E. Headquarters	Apr. 22–Apr. 23	Rudolph F. Gagg
III	Lewisburg	Lewisburger Hotel	Apr. 25–Apr. 26	A. R. Stevenson, Jr.
IV	Chattanooga	Read House	Mar. 30–Mar. 31	Edward E. Williams
V	Toronto	Royal York Hotel	May 8–May 9	Samuel R. Beitler
VI	South Bend	La Salle Hotel	Apr. 17–Apr. 18	Thomas S. McEwan
VII	Portland, Ore.	Portland Hotel	Apr. 12–Apr. 13	J. Calvin Brown
VIII	New Orleans	St. Charles Hotel	Apr. 6–Apr. 7	Linn Helander

TIME: 9:30 a.m. for all meetings except Group II, which will be 5:30 p.m.

President's Page

Faith of the Engineer

ENGINEERS are always expected by their countrymen to carry their full share of the load in national crises. Great as was the urge to co-operation during the war, when we were aware of common danger, the challenge of living and growing together in peace is still greater in these postwar days. The need for national well-being, for the common good in which all share, is a challenge to our citizenship and our human relationships. Our acceptance of this challenge is an act of faith.

The work of the engineer is based on faith: Faith in the natural laws governing the universe; faith in the ability of men to design, construct, and operate machines based on these laws; faith that men can modify their physical environment; faith that backbreaking toil can be transferred to machines.

The nature of the engineer's training establishes his faith in truth and integrity. His confidence in the future is strong. He believes that through education men may attain wisdom and understanding, and may learn to live together in peace. As a citizen, in a unique position in our industrial society, he believes in the dignity and intelligence of the individual. Conscious of the dependence of his fellow men on engineering, he feels responsibility for serving them.

Wars, whether between individual human beings or between nations, begin in the minds of men. The faith of the engineer is based on mutual trust and fair dealing. The engineer pledges his gifts to help bring about understanding and confidence in troubled situations.

In spite of crises now upon us and yet to come, the faith of the engineer is unshaken as he faces the problems of reconstruction.

D. ROBERT YARNALL, *President*, A.S.M.E.

A.S.M.E. Technical Committees Report Progress

A TEST CODE for fans intended to serve as a guide for tests on blowers, fans, and exhausters on the centrifugal, axial, and some mixed-flow types, was approved by the executive committee of the Council and will be published as a standard practice of the A.S.M.E. A pamphlet "Test Code for Fans" will soon be available at $0.90 per copy.

Members of The American Society of Heating and Ventilating Engineers and the National Association of Fan Manufacturers served with members of A.S.M.E. on the committee which developed the new code.

Nomenclature for Milling Cutter Teeth

Sectional Committee B5 of the American Standards Association has completed the proposed American Standard on Nomenclature for Milling-Cutter Teeth. This is the eighteenth American Standard completed by this committee since its organization in 1922.

The new standard, designed to serve as a supplement to the American Standard for Milling Cutters and the American Standard for Terminology and Definitions for Single-Point Tools is before the sponsor organizations for approval. The sponsors are: The American Society of Mechanical Engineers, Society of Automotive Engineers, and the National Machine Tool Builders' Association.

Involute Splines

A proposed revision of American Standard for Involute Splines has been completed by Sectional Committee B5 on Standardization of Small Tools and Machine Tool Elements. If approved by the 36 members of this committee, the proposed revision will be submitted for approval to the sponsor organizations, A.S.M.E., S.A.E., and N.M.T.B.A. When approved by the sponsors, the proposed revision will be submitted for final approval as an American Standard to the American Standards Association.

Tool-Life Tests

After six years of hard work, the technical committee on Standardization of Tool-Life Tests for Single-Point Tools is approaching the end of its assignment. Their proposal has been approved by a letter ballot of Sectional Committee B5, also by the sponsor bodies: A.S.M.E., S.A.E., and the N.M.T.B.A. Approval and designation of the proposal as an American Standard is being considered by the American Standards Association.

Gear Tolerances and Inspection

A proposed American Standard for Inspection and Tolerances for Gears, B6–1946, has been completed by the American Gear Manufacturers Association and The American Society of Mechanical Engineers. The proposed standard is before the A.S.A. for consideration. It should be available soon. Price per copy will be $0.65.

Slotted Head Proportions

Revision of the present American Standard for Slotted Head Proportions: Machine Screws, Cap Screws, and Wood Screws was completed in January, 1946. The revised draft has been submitted to Sectional Committee B18 of the A.S.A. and to industry in general for criticism.

The draft proposal is a complete revision of the present standard and covers not only head dimensions, but the dimensions of the entire product as well as dimensions of two types of cross-recessed heads.

Plumbing Code

The A.S.M.E. jointly with the American Public Health Association developed and published six standards during the past several years for the proposed American Standard Code of Minimum Requirements for Plumbing. The joint committee is currently editing the 14 sections of the proposed American Standard Plumbing Code for publication.

Tolerances for Interchangeable Manufacture

Work is in progress on a proposed American Standard for Design and Dimensioning With Tolerances for Interchangeable Manufacture. This work was prompted by a paper, "Drafting-Room Practice in Relation to Interchangeable Components," by C. A. Gladman, read before many A.S.M.E. Sections during January and February, 1945.

Cutting of Metals

A bibliography on cutting of metals prepared by Dr. Orlan W. Boston, under the auspices of the A.S.M.E. Research Committee on Metal Cutting Data and Bibliography, is available for $6.50 per copy.

The volume contains literature on the subject for the period from 1864 to 1944 and includes 4124 annotated references. It is designed as a companion volume to the "Manual on Cutting of Metals."

Pipe Threads

The American Standard for Pipe Threads which has been in the process of revision and extension by the A.S.M.E. since 1942, was approved by the A.S.A. in December, 1945. Pamphlet copies will be available shortly.

Conveyers and Conveying Machinery

Work on the proposed American Standard Safety Code for Conveyers and Conveying Machinery is continuing. The text is now under review.

Riveted Joints

A bibliography covering the literature published between 1837 and 1944 on the subject of riveted joints is available in book form. Prepared by A. E. Richard de Jonge, the volume contains a critical review of the literature on riveted joints and abstracts of the most important papers. The volume sells for $4.50.

Unfired Pressure Vessels

Complete revision of the A.S.M.E. Code on Unfired Pressure Vessels is under way. The revised draft will consist of a comprehensive treatment of the subject and will stress improved arrangement of the material. The draft will soon be submitted to the A.S.M.E. Boiler Code Committee for study.

Letter Symbols of Chemical Engineering

The draft of the proposed American Standard for Nomenclature for Chemical Engineering Unit Operations has been completed. The draft is now before the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Association for the Advancement of Science, and the Society for the Promotion of Engineering Education for approval.

The American Institute of Chemical Engineers and 35 other organizations co-operated in developing the proposed Standard.

Elevator Inspector's Manual

The revised edition of the "Elevator Inspector's Manual, B17–1945" was approved by the American Standards Association and is now available in bound-pamphlet form. The price is $1.25 per copy.

Two appendixes of the revision are available: "Descriptions and Schematic Layouts of Various Types of Under-Car Safeties and Governors" (Bulletin No. 5, $0.40); "Handling and Socketing of Wire Rope" (Bulletin No. 6, $0.25). Both are sold for $0.50.

Drawing and Drafting-Room Practice

The revised draft of the present "American Standard for Drawing and Drafting-Room Practice, Z14.1–1935" has been completed and is before the American Standards Association for approval.

The A.S.M.E., the Society for the Promotion of Engineering Education, and 27 other national organizations who co-operated in developing the draft, have approved the revision and extension of the old standard.

Shaft Couplings

Good progress was made during 1945 in the complete revision of American Standard, B49–1932, which covers the dimensions of couplings, bolts, and flanges for large integrally forged shaft couplings such as are used for the connections between the generator and turbine in hydroelectric installations.

"The Cover"

THE staff has been rewarded by favorable comment on the selection of photographs used on the cover of MECHANICAL ENGINEERING. To preserve the character of the cover all printing matter on the photographs has been avoided. Instead, a brief description is given on the contents page of the magazine. Members who enjoy the cover photographs will find subject matter described in the first item in the table of contents under "The Cover."

D. Robert Yarnall Honored By Pi Tau Sigma Fraternity

PRESIDENT D. Robert Yarnall was inducted honorary member of the Pi Tau Sigma fraternity, Lehigh Chapter, honorary mechanical-engineering fraternity, in a ceremony held in the Packard Building, Lehigh University, Thursday afternoon Jan. 31, 1946. Honorary membership was also conferred on A. R. Stevenson, Jr., vice-president, A.S.M.E. Region III.

After dinner at the College Dining Hall, Mr. Yarnall inspected the University's gage laboratory which contains over $50,000 worth of measuring equipment, recently acquired from the Philadelphia Ordnance District. Later he spoke before 150 student members and members of the Anthracite-Lehigh Valley Section at a joint meeting of the Lehigh University and Lafayette College Student Branches.

At the suggestion of Prof. F. V. Larkin, honorary chairman of the Lehigh University Branch, Mr. Yarnall spoke on "Faith of the Engineer" during which he followed closely the talk he made on a radio broadcast from Station WGY, Schenectady, N. Y., Jan. 30, 1946.

Mr. Stevenson, addressing his remarks directly to the student members, stressed the need of thorough basic preparation for an engineering career. For an engineer, he said, study and development was a never-ending program.

The Pi Tau Sigma fraternity for several years has conferred honorary membership on distinguished members of the A.S.M.E. Each year the fraternity bestows the Pi Tau Sigma Award on a deserving mechanical engineer under 35 years old. Because of the war no award was made in 1945.

1945 A.S.M.E. Annual Meeting Attendance

OFFICIAL attendance figures for the A.S.M.E. Annual Meeting held in New York, N. Y., Nov. 26 to 29, 1945, show a registration of 3753. This is a reduction of 18 per cent from the all-time high of 4584 attained during the 1944 Annual Meeting. In view of the fact that decision to hold the meeting was taken late in September and considering difficulties of travel and hotel accommodations, this reduction is not surprising.

Of this number, 52 per cent were members from 37 states and three foreign countries; 36 per cent were guests from 28 states, one territory, and seven foreign countries; seven per cent were students from 11 states; and five per cent were women from 21 states and one foreign country.

In a breakdown of membership registration by states, New York stands first with 790, of which 534 were from the Metropolitan Section; Pennsylvania second with 294; Massachusetts third with 155; New Jersey fourth with 150; Illinois fifth with a flat 100; and Connecticut sixth with 98.

Among those who came the longest distance in the greatest numbers, California comes first with 19 members and eight guests; Wisconsin comes next with 21 members and 10 guests; and Missouri third with 18 members and five guests.

Sylvanus Albert Reed Award Conferred on A.S.M.E. Member

CHARLES S. DRAPER, member A.S.M.E., professor of aeronautical engineering in charge of instrumentation, Massachusetts Institute of Technology, Cambridge, Mass., received the Sylvanus Albert Reed Award for 1945 "for application of gyroscope in computing sights for gunnery and to other computing devices."

Presentation was made by Hugh L. Dryden, member A.S.M.E., assistant director of the National Bureau of Standards and chief of its mechanics and sound division, at the honors-night victory dinner of the Institute of Aeronautical Sciences held at the Waldorf-Astoria Hotel, New York, N. Y., Jan. 28, 1946.

The award is given annually by the I.A.S. for notable contributions to the aeronautical sciences resulting from experimental or theoretical investigations, the beneficial influence of which is apparent on the development of practical aeronautics.

New Members Join Staff of Franklin Institute

A NEW administrative staff will join The Franklin Institute, Philadelphia, Pa., in April, 1946, to assist Henry Butler Allen, secretary and director of the Institute.

Charles H. Greenall, lieutenant colonel, U. S. Army, director and officer-in-charge, Frankford Arsenal, will take over the duties as executive director of The Franklin Institute Laboratories under the over-all supervision of Dr. Allen.

Rupen Eksergian, chief consulting engineer, Edward G. Budd Manufacturing Company, and W. F. G. Swann, director of the Bartol Research Foundation of The Franklin Institute, will serve as senior consultants.

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, Jan. 29, 1946

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held at Society headquarters, New York, N. Y., on Jan. 29, 1946. There were present: D. Robert Yarnall, chairman; D. S. Ellis, J. N. Landis, E. J. Kates, directors at large; A. R. Stevenson, Jr., vice-president; A. D. Bailey, past-president; W. H. Sawyer (Finance); A. R. Mumford (Sections); G. L. Knight (Organization); C. E. Davies, secretary; and Ernest Hartford, executive assistant secretary.

Professional Divisions

The appointments of chairmen and secretaries of executive committees of professional divisions were noted and confirmed. The list of these appointments is published on page 275 of this issue.

Research Committee

Upon recommendation of the Research Committee, authorization was voted to accept the invitation of W. Spraragen, executive secretary, Welding Research Council, to join with the American Institute of Electrical Engineers, the American Welding Society, and other Founder Societies of the Engineering Foundation in sponsoring the Welding Research Council. The purpose of the Welding Research Council is "to assemble, digest, and publish available information regarding welding research; to correlate existing programs in universities, governmental and industrial laboratories; and to stimulate and conduct needed research in the welding field."

Research on Pressure Vessels

Upon recommendation of the Research Committee and with the endorsement of the Boiler Code Committee, acceptance was authorized of the invitation of the Welding Research Council to join with the American Institute of Electrical Engineers and the American Welding Society in sponsoring research on pressure vessels.

Development Fund

Increase of the Development Fund of $1000 since the last report on Dec. 20, 1945, was noted. The fund now amounts to $105,779.

Test Code on Fans

Upon recommendation of the Power Test Codes Committee, it was voted to approve for adoption as a standard practice of the Society the Test Code for Fans.

Rochester Section Resolution

A resolution of the Rochester Section, paying tribute to the memory of Frank W. Lovejoy, member A.S.M.E., who died on Sept. 24, 1945, after a long period of service in the Rochester Section, was noted.

Vice-Presidents

The progress being made by the vice-presidents in taking over their responsibilities under the revised constitution and in organizing the meetings of the Regional Administrative Committees was noted. It was agreed to hold a meeting of the vice-presidents, possibly at the Chattanooga Spring Meeting, April 1 to 3, 1946, in place of the usual Council meeting. It was suggested that at least one representative of the Committee on Sections and the Committee on Relations With Colleges be present.

Nuclear Energy Application

A report by Alex D. Bailey, past-president, A.S.M.E., on a meeting of the preliminary planning committee on nuclear energy application held on January 28, 1946, was presented.

It was agreed that the Society should establish immediately a program of education and discussion throughout the entire range of the Society's activities, and that a permanent committee should be set up to follow the current progress in the art and inform the various agencies of the Society as to matters of concern to them.

It was voted to establish a Committee on Nuclear Energy Application to consist of Alex D. Bailey, A. L. Baker, G. B. Pegram, A. R. Stevenson, Jr., and W. I. Westervelt. This committee was authorized to stimulate and develop a continuing program of Society activity dealing with the application of nuclear energy.

Economic Status of the Engineer

Upon recommendation of the Engineers' Joint Council, the objectives of the Committee on Economic Status of the Engineer were approved.

Coffin and Swope Foundation

On invitation by the General Electric Company to designate a representative to act with the representatives of the National Academy of Sciences, American Chemical Society, American Physical Society, American Institute of Electrical Engineers, and the Society for the Promotion of Engineering Education, in making grants of the fellowships established by the General Electric Company, it was voted to confirm Society participation in the Coffin and Swope Foundation by the appointment of a representative.

It was further voted to approve the appointment of Alex D. Bailey, past-president A.S.M.E., as representative of the Society on the Coffin and Swope Foundation committee.

Edison Centennial Committee

It was voted to accept the invitation to serve on the Thomas A. Edison Centennial Committee extended to D. Robert Yarnall, president; Alex D. Bailey, past-president; and C. E. Davies, secretary.

Weather Bureau

Upon invitation from Charles F. Sarle, Weather Bureau, Washington, D. C., acceptance was authorized of an invitation to participate in the program of the Weather Bureau to provide essential climatological service for the building-construction and aviation industries. W. F. Davidson and R. L. Goetzenberger were designated representatives of the Society.

Metals Engineering Division

Upon recommendation of the Metals Engineering Division and with the approval of the Committees on Professional Divisions and Publication, the following appointments to the Metals Engineering Board were confirmed: L. K. Sillcox, chairman; F. B. Bell; O. J. Horger; H. B. Lewis; Taylor Lyman; P. E. Needham; Erik Oberg; Richard B. Smith; T. H. Wickenden; and J. E. Young.

Chairmen and Secretaries of Executive Committees of A.S.M.E. Professional Divisions for 1946

Division	*Chairman*	*Secretary*
Applied Mechanics	H. Poritsky, General Electric Company, Schenectady, New York.	H. W. Emmons, Harvard University, Cambridge, Mass.
Aviation	F. K. Teichmann, Guggenheim School of Aeronautics, New York University, New York, N. Y.	John E. Younger, University of Maryland, College Park, Md.
Fuels	J. E. Tobey, Upper Monongahela Valley Association, New York, N. Y.	D. C. Weeks, Consolidated Edison Company of New York, Inc., New York, N. Y.
Heat Transfer	R. H. Norris, General Engineering Laboratories, General Electric Company, Schenectady, N. Y.	H. B. Nottage, American Society of Heating & Ventilating Engineers, Research Laboratory, Cleveland, Ohio
Hydraulic	L. J. Hooper, Worcester Polytechnic Institute, Worcester, Mass.	G. R. Rich, Chas. T. Main, Inc., Boston, Mass.
Industrial Instruments and Regulators	Ed S. Smith, Eclipse-Pioneer Division, Bendix Aviation Corporation, Teterboro, N. J.	J. C. Peters, Leeds & Northrup Company, Philadelphia, Pa.
Management	A. I. Peterson, Quality Control Department, Radio Corp. of America, Harrison, N. J.	G. M. Varga, A. Schrader's Son, Division of Scoville Manufacturing Company, Inc., Brooklyn, N. Y.
Materials Handling	F. J. Shepard, Jr. Lewis Shepard Company, Watertown, Mass.	C. H. Barker, Jr. New York, N. Y.
Metals Engineering	R. D. Brizzolara, American Steel Foundries, Chicago, Ill.	J. F. Young, General Electric Company, Bridgeport, Conn.
Oil and Gas Power	E. J. Kates, Diesel Specialist, New York, N. Y.	L. N. Rowley, McGraw-Hill Publishing Company, Inc., New York, N. Y.
Power	J. A. Keeth, Kansas City Power and Light Company, Kansas City, Mo.	G. B. Warren, Turbine Department, General Electric Company, Schenectady, N. Y.
Process Industries	C. F. Kayan, Columbia University, New York, N. Y.	T. R. Olive, McGraw-Hill Publishing Company, Inc., New York, N. Y.
Production Engineering	J. L. Alden, Western Electric Company, Inc., Kearny, N. J.	C. L. Tutt, Jr. McGraw-Hill Publishing Company, Inc., New York, N. Y.
Railroad	K. F. Nystrom, C.M.St.P. & P.R.R. Company, Milwaukee, Wis.	E. L. Woodward, *Railway Age*, Chicago, Ill.
Rubber and Plastics	James H. Booth, Thompson Products, Inc., Detroit, Mich.	H. M. Richardson, Plastics Products, Pittsfield, Mass.
Textile	C. D. Brown, Draper Corporation, Hopedale, Mass.	W. Arthur Smith, Jr., Torrington Company, Boston, Mass.
Wood Industries	(To be appointed)	(To be appointed)
Group		
Consulting Engineering	M. K. Wilberding, Wilberding Company, Inc., Washington, D. C.	(To be appointed)

A.S.M.E. Studies Nuclear Energy Applications

ACUTELY aware of the engineering problems involved in the application of nuclear energy to industry, the A.S.M.E. has organized a Committee on Nuclear Energy Application under the chairmanship of Alex D. Bailey, past-president, A.S.M.E., to stimulate and develop a continuing program of activities dealing with the application of nuclear energy.

Other members of the committee are: A. L. Baker, general manager, Kellex Corporation, New York, N. Y.; G. B. Pegram, professor of physics, Columbia University, New York, N. Y.; A. R. Stevenson, Jr., General Electric Company, Schenectady, N. Y.; and W. I. Westervelt, Ross and Company, New York, N. Y.

Late in 1945 a preliminary committee set to work surveying the field of nuclear physics in order to recommend the approach the Society should take in developing the industrial use of nuclear energy. At a meeting on Jan. 28, 1946, the committee concluded: (1) That application of nuclear energy was a matter of important concern to the A.S.M.E.; (2) that in the future 98 per cent of nuclear energy applications would be industrial rather than military; (3) that government control on secrecy was a temporary condition and in the long run would not hamper development; and (4) that nuclear energy promises to set a new level of performance in industry.

On the basis of these conclusions the permanent committee was organized. It will follow the current progress in the field of nuclear energy and inform various agencies of the Society about matters of concern to them. When problems take definite form, the committee will consider the feasibility of a research program.

Classic Motion-Study Films of Frank B. Gilbreth Available

FRANK B. GILBRETH, father of motion study, used film to record the experiments upon which he based his principles of motion study and industrial engineering. Although these films are considered as classics in the field of motion study, they have been seen only by friends and clients of Mr. Gilbreth.

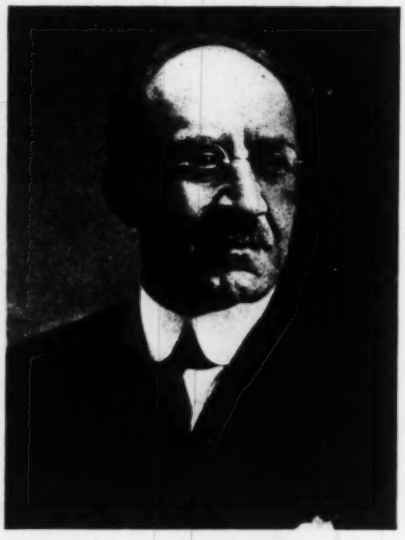
After five years of intensive research sponsored by The Society for the Advancement of Management, 350,000 feet of the original 35-mm pictures taken between 1905 and 1924 have been condensed to a 1200-foot 16-mm film, "The Original Films of Frank B. Gilbreth."

Such significant studies as "Frederick Taylor's Pig-Iron Carrying Experiment" are shown in the film.

Copies of this film can be obtained by universities and business and industrial organizations from the Chicago chapter of The Society for the Advancement of Management at a cost of $75. The film will be loaned by the Bureau of Visual Instruction, University of Iowa, Iowa City, Iowa, at the University's film-library rate of $4.

Lionel S. Marks Undertakes A.S.M.E. Lectureship

A.S.M.E. sections and other engineering communities in the South and Far West will have the privilege of hearing the lecture, "Jet Propulsion and Rockets," given by Dr. Lionel S. Marks, Fellow A.S.M.E., professor-emeritus of mechanical engineering, Harvard University, now on a lecture tour extending from Spokane, Wash., down the west coast through Texas and the Deep South and terminating at Raleigh, N. C.



LIONEL S. MARKS

Dr. Marks is an able and provocative speaker. Wherever he has given the lecture, his timely subject has attracted large audiences. Illustrated by lantern slides and followed by a discussion period, Dr. Marks's lecture has evoked enthusiastic response from A.S.M.E. members and has set a high standard for section technical meetings.

Dr. Marks has already spoken at Salt Lake City, Utah; Spokane, Wash.; Seattle, Wash.; Portland, Ore.; San Francisco, Calif.; Los Angeles, Calif.; Tulsa, Okla.; Dallas, Tex.; and Houston, Tex. He will continue to the following sections:

Monday, March 4, New Orleans, La., Section

Friday, March 8, Birmingham, Ala., Section

Tuesday, March 12, Chattanooga, Tenn., Section

Thursday, March 14, Atlanta, Ga., Section

Monday, March 18, Greenville, S. C., Section

Tuesday, March 19, Charlotte, N. C., Section

Thursday, March 21, Raleigh, N. C., Section

This arduous schedule is a tribute to Dr. Marks's physical stamina and his loyalty to the Society.

Library Selects Books for Norwegian Bookseller

WHEN John Grundt Tanum, president of the Norwegian Booksellers Association and operator of one of the largest bookselling establishments in Oslo, Norway, learned that American books were again available, he amazed American publishers by placing an order for $25,000 worth of books, of which 35 per cent were to be American technical books of the professional level.

The Engineering Societies Library through its service bureau is working on a selection of significant American technical books of recent publication to be included in this order. Ralph H. Phelps, acting director of the Library, said this was the first time the Library was asked to select stock for a foreign bookseller, and that Mr. Tanum's specific preference for American technical books indicated the prestige of American technology in Europe. Approximately 1800 to 2000 technical volumes are involved.

The service bureau of the Library operates on a nonprofit basis. It is organized to make extensive searches, provide translations from foreign journals, and to arrange for photostating of library material. While ordinary library services are free to members, a small fee is charged for special services.

To call attention to American books, the United States International Book Association, Incorporated, opened two book-display shops, one in Paris, France, and the other in Stockholm, Sweden. Hoping for a modest display of interest, American booksellers were taken unawares by the timing and magnitude of the Norwegian order. American technical books are expected to become an important item in foreign trade.

Daniel Guggenheim Medal for 1945 Awarded to T. P. Wright

THE Daniel Guggenheim Medal for 1945 and honorary fellowship in the Institute of Aeronautical Sciences were conferred upon T. P. Wright, Administrator of Civil Aeronautics, at the honors-night victory dinner of the Institute held at the Waldorf-Astoria Hotel, New York, N. Y., Jan. 28, 1946. Both presentations were made by J. C. Hunsaker, honorary member A.S.M.E., chairman of the National Advisory Committee for Aeronautics.

The Daniel Guggenheim Medal was awarded for Mr. Wright's "outstanding contributions to the development of civil and military aircraft and for notable achievement in assuring the success of our wartime aircraft-production program."

Mr. Wright was awarded the Wright Brothers Medal of the Society of Automotive Engineers in 1931.

Honorary fellowship is one of the highest honors awarded by the Institute of Aeronautical Sciences. Not more than one honorary fellow residing in the United States is elected in any one year.

A.S.M.E. Membership Is Growing

SOCIETY membership stands today higher than at any time since 1932 when a numerical peak of 20,246 was reached.

A comparison with the figures of 1936, the low point of membership, shows that the Society has grown from thirteen to twenty thousand during the last ten years. The increase year by year has been irregular and seems to reflect the years of industrial prosperity and recession. In 1937, the year of a short-time business boom, the Society gained 610 members; in 1938 this dropped to 85; in 1941, when industry began to convert to wartime production, the Society gained 1156 members; and in 1945, engineers to the number of 1393 joined the A.S.M.E. The general trend during the past four years has been consistently upward.

A new A.S.M.E. Membership List containing both alphabetical and geographical listings is scheduled for publication during 1946. Members are urged to send in the necessary data so that the list can be as accurate and complete as possible.

Vannevar Bush Receives Washington Award for 1946

THE Washington Award for 1946 was conferred upon Vannevar Bush, administrator, electrical engineer, and president, Carnegie Institution of Washington, D. C., by the Western Society of Engineers at a dinner held at the Palmer House, Chicago, Ill., Feb. 20, 1946.

The award was made in recognition of Dr. Bush's research activities which contributed to the well-being of humanity by producing devices and instrumentalities which hastened the end of the war.

Thomas S. McEwan, member and vice-president A.S.M.E., headed the Chicago Section, A.S.M.E., delegation and represented the Society at the presentation dinner.

While retaining his position with Carnegie Institution, Dr. Bush was appointed by the late President Franklin D. Roosevelt in 1940 chairman of the National Defense Research Committee, a governmental agency established for the purpose of supplementing the work of the Army and the Navy in developing devices and instrumentalities of war.

A year later Dr. Bush was made director of the newly established Office of Scientific Research and Development and was responsible for mobilizing the scientific effort of the country, and advising the President on the status of scientific research and developments.

The Washington Award is conferred each year by the Western Society of Engineers on the recommendation of commission of award representing the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and the Western Society of Engineers.

Future of Atomic Energy Discussed by Noted Physicist

SIX HUNDRED fifty members and guests of the Metropolitan Section heard John Archibald Wheeler, associate professor of physics, Princeton University, speak on "The Future of Atomic Energy" in the auditorium of the Engineering Societies Building, New York, N. Y., Jan. 20, 1946. The lecture was sponsored by the Metals Division of the A.S.M.E. Metropolitan Section. George G. Hyde, chairman of the division, presided.

JOHN A. WHEELER

Dr. Wheeler contributed to the development of nuclear energy by solving mathematically the mechanics of nuclear fission. After taking his doctorate at Johns Hopkins University in 1933, he spent a year in Copenhagen, Denmark, working in the laboratory of Niels Bohr, the famous Danish physicist.

Hanford Plants

Dr. Wheeler sketched the outline of the future nuclear-energy power plant, enumerating six ways in which such a plant will be similar to the atomic-energy plants of the Hanford Engineer Works of Hanford, Wash., located on the Columbia River about halfway between the Grand Coulee and the Bonneville dams. Although the Hanford plants were not designed for power purposes but for the manufacture of plutonium for atomic bombs, the atomic pile reaction it uses releases great amounts of energy.

Dr. Wheeler said that any future nuclear power plant would require: (1) the same kind of fission; (2) must have a similar basic material to undergo fission; (3) must produce similarly a new fissionable material; (4) must use the same kind of raw material, uranium or possibly thorium; (5) would require an auxiliary chemical plant to purify some of the charge; (6) and finally, would require heavy shielding.

About shielding he said, "I am sorry to report that the required shielding weighs a great deal. Even for a unit generating as little as 100 kw, the shielding has a thickness of a number of feet and weighs of the order of magnitude of 50 tons."

National Security

Dr. Wheeler emphasized that national security lay in productive capacity and know how. He said, "Our true security lies not in secrecy, but in a strong industrial development of nuclear energy."

While government must control all fissionable materials as an obvious condition for national security, he explained that the complexity of nuclear-energy release requires healthy competitive development of nuclear energy by qualified industries to increase industrial know how and manufacturing facilities. That problem, he concluded, was the responsibility of the engineers.

Dr. Wheeler's talk will be printed in a later issue of MECHANICAL ENGINEERING.

Howard Coonley Heads A.S.A. Executive Committee

HOWARD COONLEY, associate member A.S.M.E., will head the Executive committee of the American Standards Association, recently organized to meet the increased responsibilities placed upon the Association by a committee of industrial executives in a report to the Secretary of Commerce.

Mr. Coonley's committee will have charge of financial, administrative, and executive direction of the A.S.A. Serving with Mr. Coonley will be: Henry B. Bryans, president A.S.A. and vice-president, Philadelphia Electric Company; Frederick R. Lack, vice-president, A.S.A. and vice-president, Western Electric Company; Clarence L. Collens, Reliance Electric and Engineering Company; and George H. Taber, Jr., member A.S.M.E., president, Sinclair Refining Company.

Anticipating the demand for standards in the field of consumer goods, a committee of industrial executives under the chairmanship of Charles E. Wilson, president, General Electric Company, studied the role the government and industry should play in the formulation of standards.

In a report to the Secretary of Commerce dated June 1, 1945, the committee concluded: (1) The production and sale of all goods will ultimately be affected by standards; (2) standard activities involving negotiation, opinion, judgment, or compromise should be developed through technical, manufacturing, merchandising, and consumer groups on a voluntary basis; (3) such effort can most logically be coordinated by some disinterested private agency as the American Standards Association; (4) technical data required for standards formulation can best be developed through research and factual studies conducted by the federal government.

Mr. Coonley assisted the Chinese Government in organizing the Chinese War Production Board. He is also chairman of the A.S.M.E. Board of Standards and Codes, which was organized a short time ago to co-ordinate Society standardization activities.

Binghamton, N. Y., Members Organize A.S.M.E. Forum

MEMBERS in the Binghamton, N.Y., area of the Ithaca Section are on their toes reviving interest in A.S.M.E. affairs and building up the interest of qualified engineers in that diversified industrial center in the benefits of Society membership. Removed somewhat by distance from the center of gravity of the Ithaca Section, they aim to do their part in section activities by conducting technical meetings in the Binghamton area, calling upon local engineering leaders for material.

Under the leadership of W. G. Baird, Stow Manufacturing Company, members in Binghamton, N. Y., have taken two progressive steps: They have organized an A.S.M.E. Binghamton Area Forum which meets once a month to discuss Society affairs and acquaint members with Society services; they publish a monthly bulletin "Section Slants" which covers news events of interest to all members of the Ithaca Section.

At the Forum session on Jan. 23, 1946, headquarters was represented by Dean R. L. Sackett, assistant to the secretary. Dean Sackett commended the group on their initiative and suggested a number of nontechnical topics of sufficient interest to promise success in their initial venture. These were: The need for a technical institute in Binghamton, adult education; visual types of instruction in industry; and a management-labor program.

Headquarters wishes to encourage technical programs, locally inspired, that make available to industry and the community facilities and talent of Society membership.

University of Minnesota Offers Fluid Mechanics Fellowship

A FLUID mechanics research fellowship valued at $1500 per academic year, the terms of which can be extended over a two-year period, is offered by the University of Minnesota, Minneapolis, Minn. The award is sponsored by the Standard Oil Company for work to be done in the St. Anthony Falls Hydraulic Laboratory of the University.

The recipient will receive in cash over a nine months' period an honorarium of $1000. The remaining $500 will be used to pay the tuition and fees incidental to registration in the graduate school of the University. The Fellow will select his own subject in consultation with the director of the laboratory, and satisfactory to the Standard Oil Company. His thesis will be on some subject in the general field of fluid mechanics.

The St. Anthony Falls Hydraulic Laboratory is situated on Hennepin Island in the Mississippi River. It is in Minneapolis about one mile upstream of the main campus of the University.

Applicants should write to Director, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis, Minn.

N.A.F.M. Elects G. C. Derry President for 1946

THE National Association of Fan Manufacturers elected G. C. Derry, member A.S.M.E., vice-president and general manager, B. F. Sturtevant Company, Boston, Mass, president for 1946. The announcement was made at the 29th annual meeting of the Association held at Hot Springs, Va., Jan. 24 and 25, 1946.

Other officers elected were: R. H. Nelson, vice-president, The Herman Nelson Corporation, Moline, Ill.; and L. O. Monroe, secretary-treasurer.

Atmospheric Corrosion Discussed by A.S.T.M.

THE spring meeting of the American Society for Testing Materials held at Hotel William Penn, Pittsburgh, Pa., Feb. 26 and 27, 1946, was devoted to a symposium on atmospheric exposure tests of nonferrous metals and alloys and to the subject of quality control.

The A.S.T.M. sponsors, through its Committee B-3 on corrosion of nonferrous metals and alloys, exposure tests of many thousands of specimens exposed on racks to all kinds of atmospheric conditions in sites from coast to coast. Some of the specimens have been on the racks for more than ten years.

During the symposium speakers correlated a vast amount of data developed by the exposure tests and brought out the pertinent aspect of the results obtained. The program included papers on the corrosion of rolled zinc in the outdoor atmosphere, behavior of nickel and monel, and the resistance of copper alloys and aluminum-base alloys to atmospheric conditions, and the use of lead and tin out-of-doors.

The annual meeting of the A.S.T.M. will be held in Buffalo, N. Y., June 24 to 28, 1946. The program will include symposiums on the testing of parts and assemblies and the fatigue of materials.

Woman's Auxiliary Honors Mrs. Rudolph F. Gagg

MRS. RUDOLPH F. GAGG, past-president of the Woman's Auxiliary to the A.S.M.E., was guest of honor at a luncheon on Friday, Feb. 8, 1946, at the Engineering Woman's Club, New York, N. Y.

The luncheon was given by members of the Auxiliary who had served on the National Board with Mrs. Gagg during her term of office. The long table, seating twenty four, was decorated with spring flowers and ferns.

Mrs. Frederick M. Gibson spoke of the esteem and affection in which Mrs. Gagg was held by her associates. A silver vegetable dish was presented to Mrs. Gagg.

An afternoon of bridge followed the luncheon. Mrs. Crosby Field and Mrs. Randall B. Purdy were in charge of arrangements.

Engineers Hear Boiler Code Committee Secretary

REVISIONS to the A.S.M.E. Boiler Construction Code made during 1945 were discussed by J. W. Shields, secretary, A.S.M.E. Boiler Code Committee, before the December, 1945, meeting of the Engineers' Conference of the National Bureau of Casualty and Surety Underwriters, New York, N. Y.

Emphasizing that "safety" was the keystone of all boiler-code rules and regulations, Dr. Shields said, "I can report that the committee has unswervingly adhered to that principle in arriving at all of its decisions."

Dr. Shields called attention to revisions to the code made during the last year, which incorporated the intent of the "Alternate Rules for Fusion-Welded Power Boilers" into the body of the power-boiler code. While the alternate rules were introduced during the war emergency, they are based on improvements in the art and the materials of power-boiler construction. He said, "In effect, the alternate rules for welded power boilers have now become the basic minimum requirements under the A.S.M.E. Power Boiler Code for fusion-welded and seamless construction."

Dr. Shields said that all proposed revisions to the boiler code are published in MECHANICAL ENGINEERING. He urged all engineers interested in code revisions to submit their comments to the committee. Constructive and critical comment from the general public is a valuable aid to the Boiler Code Committee, he stated.

A.S.M.E. Calendar

of Coming Meetings

April 1–3, 1946
A.S.M.E. Spring Meeting
Chattanooga, Tenn.

June 3–6, 1946
A.S.M.E. Aviation
Division Meeting
Los Angeles, Calif.

June 12–15, 1946
A.S.M.E. Oil and Gas Power
Division Meeting
Milwaukee, Wis.

June 17–20, 1946
A.S.M.E. Semi-Annual Meeting
Detroit, Mich.

June 21–22, 1946
A.S.M.E. Applied Mechanics
Division Meeting
Buffalo, N. Y.

September 30–Oct. 2, 1946
A.S.M.E. Fall Meeting
Boston, Mass.

December 2–6, 1946
A.S.M.E. Annual Meeting
New York, N. Y.

Harry Wexler Receives I.A.S. Award

HARRY WEXLER, major, U.S.A., received the Robert M. Losey Award for 1945 in recognition of his contributions to the science of meteorology as applied to aeronautics. The award was presented at the honors-night victory dinner of the Institute of the Aeronautical Sciences held at the Waldorf-Astoria Hotel, New York, N. Y., Jan. 28, 1946. The Robert M. Losey Award was established by the Institute to honor the memory of the first officer in the service of the United States to die in World War II.

Richard Hutton Receives the Lawrence Sperry Award

THE Institute of the Aeronautical Sciences conferred the Lawrence Sperry Award upon Richard Hutton, chief development engineer, Grumman Aircraft Engineering Corporation, Farmingdale, L. I., "for his outstanding contributions to the development of carrier-based aircraft."

The award was presented to Mr. Hutton by Rear Admiral Luis de Florez, member A.S.M.E., assistant director, Naval Research Laboratory, Washington, D. C., at the honors-night victory dinner of the Institute held at the Waldorf-Astoria Hotel, New York, N. Y.

Mr. Hutton was largely responsible for design developments on such carrier-based aircraft as the *Wildcat* (F4F) and the *Bearcat* (F8F).

The Sperry Award, which carries an honorarium of $250, was endowed by the brothers and sisters of Lawrence Sperry, pioneer aviator and inventor, who was drowned in the English Channel as the result of a forced landing in 1923.

S.A.M. Awards for 1945

SOCIETY for the Advancement of Management awards for outstanding contributions to scientific management during 1945 were presented last night at the Society's annual dinner at the Waldorf-Astoria Hotel.

The Taylor Key award "for exceptional aid in furthering the science of management during 1945" was presented to Henry P. Dutton, member A.S.M.E., Dean of the Illinois Institute of Technology Night School, by president R. R. Zimmerman of the S.A.M.

James S. Perkins, chief of the personnel development section at Western Electric Company's Hawthorne Works in Chicago, received the Gilbreth Medal for "noteworthy contribution in the field of motion, skill, and fatigue studies."

The Harrington Emerson Trophy for 1945, an award made each year to that Chapter of the Society "which has most distinguished itself by special contributions to the field of management during the previous twelve months," was presented to the Cincinnati Chapter, through J. W. Roberts, president of the Chapter.

Bridgeport Section Sponsors Lectures on Electronics

THE Bridgeport Section demonstrated how the Society can be of service to its members and the local industrial community by sponsoring a course on "Electronics" given by Herbert L. Krauss, assistant-professor of electrical engineering, Yale University, at the Central High School, Bridgeport, Conn., during January and February, 1946.

The course consisted of five two-hour lectures each followed by a 15-minute question period. As an aid to the class a synopsis of each lecture was distributed for interim study, guidance, and future reference. The last lecture was given in Dunham Laboratory, Yale University, New Haven, Conn. There, Professor Krauss exhibited and operated many devices now used in industrial controls.

First planned as an aid to members of the Section, the lectures proved so popular that all interested engineers were permitted to enroll. Instead of the estimated enrollment of 25 to 35, the number reached 112 by the time of the third lecture.

Breakdown of enrollment showed twenty A.S.M.E. members, one former member, and two who were applying for membership. Seventeen Connecticut industries were represented. Of the class, 55 were residents of Bridgeport, 56 were residents of nine neighboring towns, and one came from White Plains, N. Y.

William E. Hogan, chairman of the Bridgeport Section said, "By supplying this opportunity for an introduction to the field of electronics, we feel that we are creating a feeling of goodwill toward the Society and that new memberships may develop from the undertaking. In any case, we are providing ten per cent of our membership with an opportunity which is helpful, at least, while at the same time we are performing a service to the community which constitutes the Bridgeport Section."

Pressure Vessel Research Committee to Employ Full-Time Secretary

A NEW activity in "research" concerned with unfired pressure vessels, which will cover materials, design, fabrication, and the checks by inspection and tests, is getting underway.

The organization was started last year under the sponsorship of the Welding Research Council of the Engineering Foundation, whose existing contacts facilitated an earlier development of this new research program. The American Society of Mechanical Engineers is adding its sponsorship, being particularly interested in pressure vessels under the Boiler Code. The chairman of the Subcommittee on Unfired Pressure Vessels, Walter Samans, is also chairman of the new Pressure Vessel Research Committee.

After a preliminary conference held in New York, N. Y., in March, 1945, an over-all planning committee prepared a broad outline of the problems involved. From this outline the main committee will sift those problems of greatest need, based on reports of serious defects developed in service. The projects will be co-ordinated with all available data on similar problems investigated or underway in other organizations to avoid duplication.

The main committee held its first meeting on Jan. 10, 1946, and on assurance of forthcoming funds being adequate, has indicated the need of the prompt acquisition of a full-time New York headquarters secretary. This man will be expected to collect, correlate, and maintain adequate records of similar projects by manufacturers, industry, and research laboratories. With the co-operation of the main committee he will correlate the needed projects that are approved with the available research capacity in equipment and personnel of a selected number of university laboratories. Candidates for this position are requested to communicate with W. Spraragen, Director, Welding Research Council, 29 West 39th Street, New York 18, N. Y.

Candidates for the position of full-time secretary and correlator of research projects should preferably be technically trained men between the ages of 30 and 40, having a good background of scientific knowledge on the fundamental problems related to the desired projects. They need not necessarily be familiar with details of manufacture of steel, or its fabrication into pressure vessels, or their service use. Such information is expected to be acquired in this work. They should have a working knowledge of mathematics in applied mechanics to review the work of others. A knowledge of metallurgical research procedure will be helpful. Salary will be $7000 minimum.

Offers Advanced Lighting Course

A SERIES of ten lectures on advanced lighting is being offered by the New York Sections of the American Institute of Electrical Engineers and the Illuminating Engineering Society. The lectures will be delivered at the Engineering Societies Building, New York, N. Y., from Wednesday, Jan. 9, to March 13, 1946, inclusive, from 7 to 9 p.m. Tuition fee is $6 for members of A.I.E.E. and I.E.S., and $12 for nonmembers of these societies.

N.A.C.A. Electrons

T. P. WRIGHT, Administrator of Civil Aeronautics, was elected vice-chairman of the National Advisory Committee for Aeronautics, at a formal meeting of the N.A.C.A. on Oct. 25, 1945. Dr. J. C. Hunsaker, honorary member, A.S.M.E., was re-elected chairman.

Dr. Hunsaker was also elected chairman of the Executive Committee; and Francis W. Reichelderfer, chief of the U. S. Weather Bureau, was elected vice-chairman.

John M. Hancock Awarded Gantt Medal

JOHN M. HANCOCK, partner in Lehman Brothers, and co-author of the Baruch-Hancock Report, has been awarded the 1945 Henry Laurence Gantt Memorial Gold Medal "in recognition alike of his contribution to the formulation of national economic policy and of his incisive influence on management thought and action in demonstrating that maximum effectiveness in business and industrial organization can be achieved only through wise development of the company's manpower to performance of its full potentialities."

The award will be made at a dinner to be held on October 10, at the Waldorf-Astoria in New York, N. Y., in conjunction with a two-day conference on general management under the sponsorship of the American Management Association.

The Gantt Medal was established in 1929, through a fund raised by a group of Mr. Gantt's friends, to memorialize the achievements of this great management engineer, industrial leader, and humanitarian. The Medal is administered by the Gantt Medal Board of Award consisting of representatives of the American Management Association and The American Society of Mechanical Engineers.

Refrigeration Institute Established by York Corporation

AN Institute of Refrigeration and Air Conditioning has been established by the York Corporation, York, Pa., manufacturers of refrigeration and air-conditioning equipment, to provide for its employees an educational program in engineering, production, sales, service, and factory management.

The Institute has a potential capacity of 1000 students and will provide courses ranging in duration from a five-year co-operative engineering course leading to mechanical and industrial engineering degrees, to a two-week "refresher" course.

Stewart E. Lauer, president, York Corporation, said that only through intensive and continuing study can those in the rapidly expanding refrigeration and air-conditioning field hope to pass on to the public the benefits of the newest advances in design, manufacture, and service. He said that students will be paid by the Corporation while they attend the Institute.

Detroit Section Working on A.S.M.E. Semi-Annual Meeting, June 17–20

THE A.S.M.E. Detroit Section is well ahead in preparations for the A.S.M.E. Semi-Annual Meeting to be held at the Hotel Statler, Detroit, Mich., June 17 to 20, 1946.

J. W. Armour, past-president of the Detroit Section, has been chosen chairman of the general committee to work with the national officers in planning the meeting. Mr. Armour has a group of approximately 50 members at work on various committees. These include: program planning, inspection trips, hotel arrangements, information and registration, reception and entertainment.

One of the high lights of the meeting will be the sight-seeing and inspections trips. Ford's Greenfield Village, the Edison Institute, Dearborn Inn, Willow Run airport and plant, and a steamer trip on the Detroit River are among the events in store for visitors.

Crosby Field Awarded Medal of Legion of Merit

THE medal of the Legion of Merit was presented to Col. Crosby Field, fellow A.S.M.E. by Lieutenant General Levin H. Campbell, Jr., U.S.A., Chief of Ordnance, in the board room of the Irving Trust Company, New York, N. Y., Jan. 15, 1946. During the war Col. Field served as traveling supervisor of loading plants, inspection section, Gun Division, and later as active chief, explosives loading and chemical section, Inspection Division.

Dr. Edward U. Condon Heads Specifications Board

DR. EDWARD U. CONDON, director, National Bureau of Standards, has been appointed chairman of the Federal Specifications Board. He succeeds Dr. Lyman J. Briggs, director emeritus of the National Bureau of Standards, who recently retired from the government service.

Dr. Condon was a member of the original committee established by the late President Franklin D. Roosevelt to study the possibility of using atomic energy in warfare and he was recently named technical adviser to the special Senate committee of atomic energy.

The Federal Specifications Board was established by the Director of Procurement in August, 1945, and is composed of representatives of 10 government agencies. In conjunction with the standards branch of the procurement division, it is responsible for the preparation of purchase specifications for supplies used by the federal government.

GENERAL COMMITTEE OF THE A.S.M.E. SEMI-ANNUAL MEETING DETROIT, MICH., JUNE 17–20, 1946

(*Seated left to right:* R. K. Weldy, vice-chairman; Mrs. P. W. Thompson, chairman of womens' committee; J. W. Armour, chairman; A. C. Pasini, general secretary; C. J. Freund, vice-chairman. *Standing left to right:* H. E. Gandelot, chairman of information and registration committee; J. M. Geisinger, assistant secretary; R. H. Stellwagon, chairman of plant trips committee; Tom Jeffords, vice-chairman; J. H. Spurgeon, chairman of printing and signs committee; R. F. Hanson, vice-chairman of plant trips committee; H. S. Walker, chairman of finance committee; A. W. Honywill chairman of technical events committee; J. F. Jarnagin, chairman of publicity committee; T. E. Winkler, chairman of entertainment.)

Midwest Quality Control Conference to Be Held March 5 and 6

A MIDWEST Quality Control Conference sponsored jointly by the Quality Control Societies of the Middle West and the Chicago Association of Commerce will be held in Chicago at the La Salle Hotel, Tuesday and Wednesday, March 5 and 6, 1946.

Methods of controlling industrial quality and performance will be discussed at the conference. Speakers include: G. D. Edwards, director of quality assurance, Bell Telephone Laboratories, New York, N. Y.; M. H. Eisenhart, president, Bausch & Lomb Optical Company, Rochester, N. Y.; and L. A. Knowler, professor, The State University of Iowa, Iowa City, Iowa.

Materials Handling Society Hears A.S.M.E. Member

THE problems incident to the handling of materials in the glass industry were discussed by Robert A. Miller, member A.S.M.E., product development department, Pittsburgh Plate Glass Company, before The Materials Handling Society at a meeting at Hotel Keystone, Pittsburgh, Pa., Jan. 21, 1946.

Mr. Miller's subject was "Handling Problems in the Manufacture of Glass." Using a motion picture which showed the complete manufacturing process from raw material to finished product, his running commentary emphasized that the entire glassmaking process was essentially a series of materials-handling operations linked together by the melting, rolling, grinding, and polishing operations.

E.C.P.D. Resolution Urges Release of Technical Manpower

CONCERNED over the critical shortage of scientific and technical men in industry and students in training in the schools, the Engineers' Council for Professional Development has drafted a resolution urging the Armed Forces to release scientists and engineers to industry and the selective-service draft boards to keep qualified young men in the schools.

The resolution, sent to John W. Snyder, director of war mobilization and reconversion in January, 1946, stated that the public welfare depended on a high order of national technological proficiency and that this in turn depended on an ample supply of trained and experienced manpower. Military requirements had depleted the ranks of scientists and engineers and had diverted the normal flow of students from the schools to the Armed Forces. If the policy of the selective-service boards continued, national interest and security would suffer. Co-operation of the legislative and executive branches of the government was essential to correct the current deficit and to assure a future supply of trained manpower to meet the problems of national reconversion, progress, welfare, and security.

The resolution urged the following action: (1) Deferment of young men in science and engineering now in training, industry, and the professions; (2) discharge of those whose training was interrupted by service in the Armed Forces; (3) discharge of those whose training has been completed and whose release would lessen the critical shortage; (4) deferment of young men about to enter accredited engineering schools. It was also urged that the President and the Congress be informed of the imperative and immediate need of replenishing scientific and engineering manpower; and that the President be asked to take steps through the selective-service procedure to insure the flow of qualified students to the colleges and the engineering, technical, and graduate schools.

The Engineers' Council for Professional Development is a conference organized to enhance the professional status of the engineer through the co-operative efforts of the following national organizations concerned with the professional, technical, educational, and legislative phases of engineers' lives: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, The Engineering Institute of Canada, The Society for the Promotion of Engineering Education, American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners.

The Engineering Institute of Canada, naturally, did not participate in the resolution.

The resolution was well received by the Office of War Mobilization and Reconversion. J. Donald Kingsley, director of manpower, informed the E.C.P.D. that the selective-service system has agreed to give special consideration to the deferment of scientists and engineers. Selective release of personnel essential for reconversion is now under discussion with the Army and Navy Departments.

R. T. Lamson and A. E. Merrill Win Octave Chanute Award

THE Octave Chanute Award for 1945, given annually by the Institute of Aeronautical Sciences, was conferred upon co-recipients, Robert T. Lamson and A. Elliott Merrill "for obtaining at great personal hazard data contributing to the design of high-altitude military aircraft." The award was presented at the honors-night victory dinner of the Institute held at the Waldorf-Astoria Hotel, New York, N. Y., Jan. 28, 1946.

The Octave Chanute Award is given annually to pilots in recognition of notable contributions to the aeronautical sciences. Established in 1939, the award honors the memory of Octave Chanute, American engineer and aviation pioneer. Mr. Lamson and Mr. Merrill obtained high-altitude flight research data which helped to increase the ceiling of four-engined bombardment airplanes.

A.S.M.E. Vice-Presidents Set Up New Regional Administrations

EIGHT vice-presidents of the A.S.M.E. are solving the administrative problems which they meet in performing their new duties under the plan of organization put into effect at the 1945 Annual Meeting of the Society. They are making excellent progress.

Although the year is but eight weeks old, Regional Administrative Committee meeting dates have been decided, an order of business has been agreed upon, sections have been visited, and much light has been shed on the new basis under which the Society must function in the future.

Linn Helander, vice-president, Region VIII, spoke at a meeting of the Kansas City Section on Jan. 15, 1946. His subject was, "Know Your Society." So impressed were the members with their new vice-president and his illuminating talk that Raymond P. Hahn, chairman of the Kansas City Section, wrote to headquarters saying, "I certainly think that the type of presentation Professor Helander made last night is one that should be made available to all sections, for it is surprising how little the average member knows about his Society."

In New Haven, Conn., on Jan. 17, 1946, Alton C. Chick, vice-president, Region I, addressed the New Haven Section on Society matters.

A. R. Stevenson, Jr., vice-president, Region III, during the past eight weeks spoke before the Syracuse, Baltimore, Washington, D. C., Philadelphia, and the Anthracite-Lehigh Valley sections of his region. On Jan. 31, 1946, he was present at the Packard Building, Lehigh University, Bethlehem, Pa., where he and D. Robert Yarnall, president A.S.M.E., were inducted as honorary members of Pi Tau Sigma, mechanical-engineering honorary fraternity. Mr. Stevenson took the opportunity to address students and members on the need for more thorough basic preparation, and said that continued study and development was a never-ending program for the successful engineer.

J. C. Adams Receives I.A.S. Award

THE John Jeffries Award for 1945 was conferred on Commodore John C. Adams, chief of the division of aviation medicine, Bureau of Medicine and Surgery, Navy Department, by the Institute of Aeronautical Sciences "for outstanding contributions to the advancement of aeronautics through medical research," at the honors-night victory dinner held at the Waldorf-Astoria Hotel, New York, N. Y., Jan. 28, 1946.

The award honors the memory of Dr. John Jeffries, an American physician who, with Blanchard the French balloonist, made the first aerial voyage across the English Channel in 1785, and was established by the I.A.S. in 1940 to give recognition to the importance to aviation of scientific endeavor in the field of medicine.

Automotive Engineers Hold Annual Meeting in Detroit, January 7 to 11, 1946

THE Society of Automotive Engineers held its annual meeting Jan. 7 to 11, 1946, at the Book-Cadillac Hotel, Detroit, Mich.

Two series of synthetic lubricants made from natural and other hydrocarbon gases were reported in a paper, "New Synthetic Lubricants," by J. C. Kratzer, Jun. A.S.M.E., Linde Air Products, Tonawanda, N. Y.; D. H. Green, National Carbon Company, New York, N. Y.; and D. B. Williams, Carbide and Carbon Chemicals Corporation, New York, N. Y. The LB series is insoluble in water and is adaptable to lubrication of machinery, including internal-combustion engines; series 50-HB is soluble in water and can be used with metals, rubber, and other materials. Tests with LB-300 and LB-500 showed cleaner engine operation because of solvent action, easier starting at low temperatures, and smaller than normal deposits. Other tests disclosed that the new lubricants were freer from sludge and varnish formation.

The 50-HB series is equal in lubricity to the LB series and is reported to be excellent for use as brake fluids, cutting oils, and textile lubricants. These lubricants are superior to German synthetics, from which they differ chemically. They are somewhat higher in cost than the best petroleum lubricants.

Tin

Warning that a continuing shortage of tin threatens to have serious effects in the United States, which consumes 40 per cent of the world supply, but produces none, C. E. Heusnner and E. T. Johnson, Chrysler Corporation, Detroit, Mich., reported that the automobile industry during the past four years reduced consumption of tin per motor vehicle from four pounds in 1940 to two pounds or less in 1945. They said that tin saving could be promoted by substituting electroplating for dipping in tin-can manufacture and by larger use of secondary tin recovered from tin-can salvage operations; from solder, babbitt, and bronze; and by decreasing the tin content of solder.

Aircraft-Engine Development

Many aircraft-engine developments are awaiting metallurgical progress to provide metals capable of withstanding temperatures of 3000 F and higher, according to Ralph L. Haver, junior A.S.M.E., and Harry A. Goodin, Ryan Aeronautical Company, San Diego, Calif., who presented a joint paper, "Design Trends in Aircraft Exhaust Systems." They said, "There is only one main stumbling block on the exhaust equipment improvement. That barrier lies in the metallurgy of available materials. There is no material available which will satisfactorily withstand the high temperature and corrosive atmospheres to which they are subjected." This is serious, they said because "it stands in the way of rapid increases in available thrust from power plants."

Aircraft Practice Applied to Motorcars

Application of aircraft design and construction techniques to motor vehicles for purposes of weight reduction and improvement in the structural use of materials was discussed by Mac Short, Lockheed Aircraft Corporation, and W. E. Miller, consulting engineer, Burbank, Calif., in a joint paper, "An Aircraft Approach to Automobile Body Design."

The use of light metals, they said, depended on how long people remained content "to wheel about 3000 lb of material to carry one or two people an average of 40 mph." Opinion was expressed that the motor-vehicle practice of mounting a heavy body atop a heavy chassis structure constitutes something less than efficient use of materials and structure. The eventual development of a unitized body and chassis may confirm the aircraft designer's theory that the lines dictated by requirements of form and those of strength of structure can be identical.

Production Techniques Vs. Production Costs

New engineering production techniques were advocated as a weapon against rising production costs. S. Johnson, Jr., Bendix-Westinghouse Automotive Air Brake Company, in a paper, "Air Fixtures and Air Controls," recommended the use of air-operated fixtures, which he said not only increased production per man-hour by more than 100 per cent, but contributed much to working safety.

Modern honing machines and techniques, which consistently hold operations to 0.0003 and often to 0.0002 in. tolerance and which remove metal 25 to 30 times faster than older honing methods, were described by L. S. Martz and D. T. Peden, Micromatic Hone Corporation, Detroit, Mich., in their paper, "Latest Developments in Honing Techniques." They said that large amounts of material can be saved and any kind of surface finish, bore-wall quality, or controlled surface roughness, produced and reproduced.

Diesels

According to F. G. Shoemaker and H. M. Gadebusch, Detroit Diesel-engine division, General Motors Corporation, Detroit, Mich., who presented a joint paper, "Effect of Fuel Properties on Diesel-Engine Performance," Diesel engines no longer could be regarded as accommodating and tolerant consumers of petroleum fuels which could not be used for other purposes. They said that the demand for smoother cleaner operation has resulted in improvements in Diesel engines which call for fuels having specific properties in order to maintain efficient and prolonged operation. Progress in fuel-refining techniques have made available in virtually unlimited quantities fuels of any desired characteristics.

Sixth International Congress for Applied Mechanics Will Meet at the Sorbonne, Paris, Sept. 22 to 29, 1946

PLANS for the Sixth International Congress for Applied Mechanics were initiated at a meeting called by Jerome C. Hunsaker, honorary member A.S.M.E., and Theodor von Kármán, member A.S.M.E., acting as joint secretaries of the Fifth International Congress for Applied Mechanics. A committee was formed to organize the Sixth International Congress which is to be held at the Sorbonne, Paris, France, from Sept. 22 to 29, 1946.

Invitations to the Congress have been extended on behalf of: l'Académie des Sciences de l'Institut de France; la Direction des Relations culturelles; le Centre national de la Recherche scientifique; l'Institut de Mécanique de la Faculté des Sciences de Paris; la Société francaise des Mécaniciens; and l'Association technique Maritime et Aéronautique.

The Applied Mechanics Division of the A.S.M.E. since its formation in 1928 has taken an active part in co-operating with the organization of American participation in the International Congresses. In 1938 when the Fifth International Congress for Applied Mechanics met in Cambridge, Mass., at Harvard University and Massachusetts Institute of Technology, the Applied Mechanics Division published in the *Journal of Applied Mechanics* abstracts in English of all the 124 papers prepared for the Congress.

Subjects to Be Discussed

The Sixth International Congress will be divided into the following sections:

(1) Structures, elasticity, and plasticity.
(2) Hydrodynamics, aerodynamics, and hydraulics.
(3) Solid dynamics, vibration and sound, and friction and lubrication.
(4) Thermodynamics, heat transfer, combustion, and fundamentals of nuclear energy.
(5) General lectures on subjects of current interest. The titles of these lectures will be made known at a later date.

The French organization committee of the Congress is composed as follows: president, Henri Villat; secretary general, Maurice Roy; members: Émile Barrillon, Louis de Broglie, Albert Caquot, Paul Dumanois, Jules Drach, Frédéric Joliot, Henri Laugier, Joseph Pérès, and Ernest Vessiot.

Early Registration Desired

Those who desire to become members of the Congress are requested to inform the secretary general as soon as possible of their intention to attend the Congress. They should also indicate at the same time whether they wish to

present a paper, and in what section. This is required in order to facilitate the preparation of the program and the issuing of further notices.

Communications are to be addressed to: Secretary General of the Sixth International Congress for Applied Mechanics, Institut Henri-Poincaré, 11, rue Pierre-Curie, Paris (V°).

Checks or money orders can be made payable to the: Sixième Congrès International de Mécanique appliquée, Institut Henri-Poincaré, 11, rue Pierre-Curie, Paris (V°). It is recommended that payments be made on the following account: Cheques postaux Paris N°. 649 (address given above).

Scientific Papers Solicited

The authors who wish to present papers are requested to submit the titles of their contributions as soon as possible. As at previous congresses, contributions must be of scientific value and pertinent to the program of the congress.

The authors are also asked to send to the secretary general, before July 31, 1946, either the manuscript of their paper (maximum 5000 words) or a summary of no more than 300 words. It is most desirable to have at least the summaries of all papers available to the members at the time of the Congress, in order to facilitate discussions. The Organization Committee hopes it will be able to have the summaries reproduced at the right time. However, it would be a great help if authors who have facilities to prepare a sufficient number of copies of their summaries, or manuscripts, would do so and send such copies to the secretary or bring them to the meeting.

The proceedings of the Congress, containing the minutes of the sessions, the texts of the general lectures and the papers presented in the Sections, will be published with the least possible delay. The members of the Congress will have the right to buy these volumes by subscription. The surplus copies will be sold later on at a higher price.

Adequate facilities will be provided for the members for their stay in Paris. Arrangements will be made known in due time. As at the previous congresses, excursions and visits to various institutions and places of scientific, historic, and artistic interest will be arranged.

The payment of an inscription fee of 300 francs is required from the members of the Congress; this fee can be paid immediately or not later than on the opening day of the Congress. Women accompanying members will not be required to pay such fee, except those who wish to address the meetings or to submit papers.

It is hoped that the success of the Fifth International Congress, which attracted some 391 engineers and scientists interested in applied mechanics from many sections of the world, will be repeated in Paris. The Applied Mechanics Division of the A.S.M.E. under the chairmanship of H. Poritsky is expected to cooperate fully in the organization of American participation in the Sixth International Congress.

Electrical Engineers Hold Winter Convention in New York, N. Y., Jan. 21–25

ATOMIC energy, peacetime applications for radar, remote control for hydraulic plants, and the development of a magnetic inertia throat microphone were some of the subjects discussed at the annual winter convention of the American Institute of Electrical Engineers held at the Engineering Societies Building, New York, N. Y., Jan. 21 to 25, 1946.

Nuclear Energy

J. R. Dunning, director, Division of War Research, Columbia University, and technical adviser, The Kellex Corporation, said that only large power plants such as those on battleships could use atomic energy effectively. He pointed out that a shield from six to eight feet thick between the atomic boiler and the workmen would be necessary to bar the radioactive waves given off. The size and weight of this protective barrier would rule out the use of atomic power in homes, automobiles, or airplanes of the present size.

"The first commercial uses of atomic energy," Dr. Dunning said, "probably will be along conventional lines to drive generators. Later it may be possible to convert atomic energy directly into electrical energy without turbines."

Speaking on the subject, "Peacetime Applications of Nuclear Energy," C. G. Suits, vice-president and director of research, General Electric Company, Schenectady, N. Y., said that atomic power for the automobile or the railroad locomotive was not yet in sight, but that atomic energy offered some attractive possibilities for large-ship propulsion. He urged all branches of the power industry to undertake development programs directed toward application of atomic power. Because equipment required for nuclear research is large and expensive, it was his opinion that government support of a long-range program of fundamental research was necessary.

Shoran Precision Radar

A short-range system of radar called "shoran," used during the war by the Armed Forces for blind bombing and aerial mapping, was described by Stuart W. Seeley, Radio Corporation of America, New York, N. Y. Mr. Seeley said, "Shoran navigational radar is generally credited with being the most precise system of its type devised by man." Because shoran makes possible accurate transmission path length measurement at short ranges it may prove of special value as an aid to blind aerial navigation and piloting in fogbound harbors.

Remote Control of Power Plant

No. 3 Occeo hydroelectric plant of the Tennessee Valley Authority, according to C. W. Bohner, International General Electric Company, and A. P. Maness, production engineer, Tennessee Valley Authority, Chattanooga, Tenn., is so completely fitted with automatic and supervisory control features that the plant can be operated from a control station five miles away.

Mr. Bohner and Mr. Maness spoke on the subject, "Supervisory Control of 30,000-Kva Hydro Plant." They said that the excellent performance and low operation cost of the No. 3 Occeo plant has encouraged the extension of supervisory control to future generating plants of larger capacity and to a number of substations.

Throat "Mikes"

A tiny superdiscriminating microphone which is highly sensitive to vibrations transmitted to it by bodily contact with the sound-producing throat but which is quite insensitive to noises transmitted by air was described by L. G. Pacent, president, Pacent Engineering Corporation, New York, N. Y., and E. H. Greibach, director of research, Sonotone Corporation, in a joint paper, "Inertia Throat Microphones." Its use in boiler factories, machine shops, and airplanes where noise levels are high and where communication must be maintained is foreseen.

Atomic Bomb Project

The two billion dollars spent on the research and manufacturing facilities of the atomic bomb should be written off the nation's books as a wartime investment. This proposal was made by Leslie R. Groves, major general, United States Army, in an address on "Some Electrical Engineering and General Aspects of the Atomic Bomb Project."

Illustrating why costs of developing the bomb ran so high, General Groves recounted an inspection trip to a research laboratory in California. During one day's experiments, three sets of eight vacuum tubes, each about the size of a man, were blown out. "Each time that happened," he said, "it cost $5000."

A.S.C.E. Holds Annual Meeting in New York, N. Y., Jan. 16–19

CIVIL Engineers at the ninety-third annual meeting of the American Society of Civil Engineers held Jan. 16 to 19, 1946, at Hotel Commodore, New York, N. Y., talked about measures of national preparedness and the problems of urban planning. The need for basic scientific research, the vulnerability of the Panama Canal, plans for the postwar Navy, and the progress of the Chicago Planning Commission were some of the subjects discussed.

National Research

Boris A. Bakhmeteff, member A.S.M.E., and honorary member, A.S.C.E., speaking at the opening dinner on the subject, "Science and Engineering," said that in the field of applied research the United States yields to no one, but in matters of basic science and in the furtherance of basic science research, the United States does not keep pace with the Old World but depends to a great extent on the initiative and inspiration coming from overseas. He said that it was Germany who first recognized the importance of fundamental en-

gineering research. Having been dangerously exposed to Germany's unprecedented technical potency, the United States is now research and science conscious and is planning a National Science Foundation.

Panama Canal

The problem of national defense was discussed by John G. Claybourn, superintendent of the Panama Canal dredging division, who presented a paper, "Streamlining the Panama Canal for Maximum Safety and Unlimited Capacity." Modern and potential weapons have made the present waterway with its locks and dam highly vulnerable. Mr. Claybourn recommended the construction of a 500-ft-wide lockless and damless sea-level canal cut across the Isthmus in accordance with the recommendation originally made in 1905–1906 by a majority of the engineers on the Panama Canal Commission. Such a canal, it is estimated, would require 12 years to construct and would cost over a billion dollars, or equivalent to five and one quarter days' wartime expenditure.

Mr. Claybourn said, "We now have the background of experience to convert our present canal to an invulnerable, indestructible sea-level canal of unlimited capacity which will insure its continuous operation in war as well as in peacetime" and insisted that "there are no problems here that cannot be solved." As proof of invulnerability, Mr. Claybourn cited the war experience of the Suez Canal where the largest ships had been passed efficiently at low cost and with practically no hazard. Although it had been blocked by sunken ships, these required only a few days to remove.

Postwar Navy

During a morning session the following day, the Navy's plans for national preparedness were outlined by John J. Manning, rear admiral, U.S.N., in a talk, "Postwar Construction Plans of the Bureau of Yards and Docks." He said that the Navy plans to divide the postwar fleet into three basic groups. The first would be the active fleet, manned by about 70 per cent of war complement; the second would be a reserve fleet manned by 30 per cent of war complement; and the third would be the inactive fleet. There would be a provision to rotate the reserve fleet periodically with the active one. The inactive fleet would be placed in a state of preservation so that it can be reactivated when necessary. He said that the Navy has adopted modern techniques for preservation, including dehumidification, protection with film preservatives, plastics, and other similar measures.

Chicago City Planning

While the cataclysmic destruction caused by the atomic bomb has convinced some planners of the need for future dismemberment of cities and the underground existence of industry, Evert Kincaid, executive director, Chicago Plan Commission, speaking on "City Planning, Zoning, and Housing," called for "faith in our peace planners" and "the preparation of realistic and practical city plans and programs geared to cope with urban problems and to guide effectively future and new growth." Mr. Kincaid said that Chicago has designed a system of expressways radiating from the central business district into and through all the major populated sections of Chicago. Connected residential areas are planned to accommodate an estimated population of almost 4 million by 1965. Each community will have its own high school, adjoining community park, and playfields. He said that this plan has already won the support of the board of education and the Chicago park commission.

Books for Mechanical Engineers, 1945

DURING the course of a year the Engineering Societies Library is asked to recommend books on specific subjects. A list of some of the significant books of interest to mechanical engineers, compiled by the staff of the Engineering Societies Library, are listed for convenience of A.S.M.E. members. Some equally good books have been omitted because of the desire for a short list.

ENGINEERING CONTRACTS AND SPECIFICATIONS. By R. W. Abbett. John Wiley & Sons, Inc., New York, N. Y., 1945, 188 pp., $2.25. Some of the legal and business aspects of the engineering profession are presented in convenient reference form with examples, forms, and suggestions for contracts and specifications. Written for practical engineers and contractors as well as college students.

FUNDAMENTALS OF THERMODYNAMICS. By A. S. Adams and G. W. Hilding. Revised edition. Harper & Brothers, New York, N. Y. 1945, 289 pp., $4. Intended for the beginning student. Discusses the thermodynamics of the internal-combustion engine, steam cycle, steam engines, and turbines.

ROLLING BEARINGS, a Comprehensive Treatise Covering History, Theory, Design, and the Practical Application and Use of Ball and Roller Bearings. By R. K. Allan. Pitman Publishing Corporation, New York, N. Y., 1945, 401 pp., $8.50.

PRINCIPLES OF FIREARMS. By C. E. Balleisen. ohn Wiley & Sons, Inc., New York, N. Y., 1945, 146 pp., $2.50. Guide to engineering fundamentals essential for the analysis, design, and construction of modern firearms.

BIBLIOGRAPHY ON CUTTING OF METALS, 1864–1943. By O. W. Boston. The American Society of Mechanical Engineers, New York, N. Y., 1945, 547 pp., $6.50. Chronological list of more than 4000 items. Includes an author index and a subject index so tabulated that various processes, and items such as cutting fluids, speeds and feeds, chip formation, finish, tear, wear, etc., may be readily found.

RIVETED JOINTS, a Critical Review of the Literature Covering Their Development, With Bibliography and Abstracts of the Most Important Articles. By A. E. R. De Jonge. The American Society of Mechanical Engineers, New York, N. Y., 1945, 250 pp., $4.50. This extensive bibliography covers the literature of fourteen countries from 1837–1944. References are arranged chronologically and there are name and subject indexes.

THE AERONAUTICAL DICTIONARY. By T. A. Dickinson. Thomas Y. Crowell Company, New York, N. Y., 1945, 484 pp., $3.50. Definitions of over 6000 terms in aerodynamics, meteorology, navigation, piloting, engineering, metallurgy, design, lofting, aircraft construction, and other phases of aeronautics. An appendix contains many tables of technical data, lists of aeronautical abbreviations, useful books, and American periodicals. Illustrated.

PRINCIPLES OF INDUSTRIAL PROCESS CONTROL. By J. Eckman. John Wiley & Sons, Inc., New York, N. Y., 1945, 237 pp., $3.50. Treats laws of operation of industrial automatic control systems and provides a practical background of theory. Details of measuring devices and controlling mechanisms are brought out only when they are necessary to the analysis of principles and characteristics of operation.

ENGINEERING PREVIEW, an Introduction to Engineering Including the Necessary Review of Science and Mathematics. By L. E. Grinter. The Macmillan Company, New York, N. Y., 1945, 581 pp., $4.50. Treats the background science of engineering—mathematics, chemistry, physics, and technical drawing—to enable the reader to orient himself and determine whether engineering is the field he should choose.

THE AUTOMOTIVE CHASSIS (Without Powerplant). By P. M. Heldt. P. M. Heldt, Nyack, N. Y., 1945, 583 pp., $6. A reference work covering the various parts of the automotive chassis, the function of these parts, their theory, the materials of which they are made, and their design.

PROCESS EQUIPMENT DESIGN. By H. C. Hesse. D. Van Nostrand Company, Inc., New York, N. Y., 1945, 580 pp., $7.50. Covers fundamentals of mechanics, machine and structural elements, and economic and manufacturing considerations related to the design of process equipment, particularly for the chemical industries.

INTERNAL-COMBUSTION ENGINES, Theory and Design. By V. L. Maleev. Second edition. McGraw-Hill Book Company, Inc., New York, N. Y., 1945, 636 pp., $5. Covers the fundamentals of internal-combustion engineering. Intended for college students and for engineers and designers.

WAVEFORM ANALYSIS, a Guide to the Interpretation of Periodic Waves, Including Vibration Records. By R. G. Manley. John Wiley & Sons, Inc., New York, N. Y., 1945, 275 pp., $4. Includes details of the basic theory and the methods of mechanical wave-form analysis and presents in detail the envelope method of analysis.

MECHANICS FOR ENGINEERS. By E. R. Maurer, R. J. Roark, and G. W. Washa. John Wiley & Sons, Inc., New York, N. Y., 1945, 425 pp., $4. A textbook on theoretical mechanics for students of engineering. Covers statistics and dynamics as usually taught at the undergraduate level.

PIONEERING THE HELICOPTER. By C. L. Morris. McGraw-Hill Book Company, Inc., New York, N. Y., 1945, 161 pp., $2.75. Popularly written story of the Sikorsky helicopter from its experimental stage until it was capable of sustained vertical flight as well as hovering, and flying backward and forward.

BALL AND ROLLER-BEARING ENGINEERING. By A. Palmgren. SKF Industries, Inc., Philadelphia, Pa., 1945, 270 pp., $1.75. Translation of a Swedish book. Covers the fundamental principles of ball-bearing engineering, including material on bearing selection, design, types of bearings, carrying capacity, mounting and dismounting, lubrication and maintenance, and bearing failures.

Sections

Talk on Russia at Akron-Canton Section

On Dec. 13, 1945, at the Y.M.C.A., Akron, Ohio, Dr. O. J. Horger, member A.S.M.E., was the featured speaker. His subject, "An Engineer Visits Russia," aroused great interest in the audience. Dr. Horger, who is now chief engineer of the railway division, Timken Roller Bearing Company, Akron, Ohio, visited Russia in 1945 and in his talk gave his impressions of the country, its people, and its industries.

Selection of Engineering Personnel Discussed at Central Illinois Section

On Jan. 10 at the University Club, Peoria, Ill., the subject was "Selection of Engineering Personnel." The speaker was Mr. Mann of the General Electric Company, who said that the methods of choosing personnel included the qualities of character, ambition, personality, appearance, and ability. These items, he said, were used to judge and sell a prospect. He explained that checks should be made at yearly intervals for five years, and two-year intervals thereafter; that the chance of getting lost in a large organization was small, and that transfer should be made until a man had found his place. One hundred and twenty-five were present.

Precision Castings Discussed by Chicago Section

John A. Gallaher, district manager, Haynes Stellite Company, Kokomo, Ind., was the speaker at the Jan. 15 meeting in the Civic Opera Building's Little Theatre, Chicago, Ill. He spoke on "Industrial Applications of Precision Castings." He presented a very fine talk, illustrated with slides, showing the development of the investment-casting method in making small metal parts. This method, also known as the lost wax procedure, has made rapid strides during the war because of the necessity of alloy parts which were very difficult to machine, and the close tolerances required on the finished part. There were 94 present. This meeting was sponsored by the Metals Engineering Division.

Colorado Section Hears "Meehanite in Industry"

The regular monthly meeting was held Dec. 14, 1945, at the Oxford Hotel, Denver, Colo. Following dinner, the chairman introduced the speaker of the evening, R. W. Akerlow, whose subject was "Meehanite in Industry." A sound film covering the various physical characteristics and applications of this material supplemented his talk. Mr. Akerlow explained that Meehanite is a controlled process of producing a superior type of cast iron, each manufacturer of which must agree to meet the standards set up by the Association of Meehanite Foundries. Following his talk, questions from the audience developed many interesting points. A number of demonstration pieces and machine parts made from Meehanite were shown.

On Jan. 11 a dinner meeting was held at the Oxford Hotel, Denver, Colo., when E. H. Musgrove spoke on the subject, "Development of Railroad Radio on the Denver, Rio Grande and Western Railroad." To illustrate his talk Mr. Musgrove showed colored movies and described experiments made on the railroad which have led to satisfactory caboose to engine, and train to wayside station radio communication. He said that on long freight trains in mountainous terrain such communication is very useful.

Detroit Section Hears Fred Lucht

On Jan. 15 in the Rackham Building, Detroit, Mich., Fred Lucht, member A.S.M.E., Carboloy Company, spoke on "Milling Steel With Carbides." Mr. Lucht covered the technical factors involved in the machine-tooling and operation for successful steel-milling. The one hundred members and guests found the extensive discussion which followed the talk very instructive. Prof. O. W. Boston, member A.S.M.E., College of Engineering, Ann Arbor, Mich., participated in the discussion.

Fort Wayne Section Presents Varied Programs

On Nov. 1, 1945, a meeting was held featuring G. E. Verhostra, Indiana distributor for Aeronca and Fairchild Companies, who spoke on "The Past, Present, and Future of the Small Airplane."

The Dec. 6 meeting was a dinner meeting at which J. H. Davidson, head of the quality-control division, Western Electric Company, Hawthorne Works, Chicago, Ill., was the speaker. He gave an interesting talk on "A Quality-Control Unit: Its Organization and Operation," and several members of the newly formed Quality Control Club of Fort Wayne, Ind., were present to hear him.

The speaker at the Jan. 3 meeting was Prof. H. L. Solberg, member A.S.M.E., head of the school of mechanical engineering, Purdue University. Professor Solberg spoke on "Gas-Turbine Power Plants," and in the course of his talk said that the greatest needs at present were for better metals and cheaper fuels. A gas-turbine unit, he explained, would be ideally suited for marine use, aeronautical use, railway, and stationary-power-plant operation.

"Magnesium and Its Alloys" Talk at Hartford Section

On Jan. 22 a dinner meeting was held at the City Club of Hartford, Conn. The program consisted of a lecture entitled "Magnesium and Its Alloys and Working of Magnesium," by James B. Reid, Dow Chemical Company, New York, N. Y. Mr. Reid, who for eleven years specialized in corrosion and chemical finishing in the metallurgical laboratory of his company, gave an interesting talk, illustrated with a sound movie.

Kansas City Section Hears Prof. Linn Helander

On Jan. 14 a meeting was held in the University Club, Kansas City, Mo., when Prof. Linn Helander, regional vice-president, A.S.M.E., spoke on "Know Your Society." He gave a report on the 1945 Annual Meeting in New York, N. Y., and also a report on the meeting in Boston, Mass., which he attended. He spoke of the duties of a regional vice-president, and also of the Council's action on the Kilgore and Magnuson Bills. These bills brought forth a prolonged discussion. The total attendance was 48.

Dean Langenheim, Speaker at Mid-Continent Section

The monthly meeting was held Jan. 29 in room 101 Engineering Building, University of Tulsa, Tulsa, Okla. R. L. Langenheim, dean of engineering, University of Tulsa, gave an address entitled "An Engineering Education for Returning Service Men." Fourteen engineers were present.

Sintered Carbides Discussed at New London Section

At the Jan. 16 meeting, held in the Mohican Hotel, New London, Conn., Malcolm F. Judkins, member A.S.M.E., chief engineer, Firthite division, Firth Sterling Steel Company, gave a talk on sintered carbides. Mr. Judkins discussed the early manufacture and uses of sintered carbides. He explained that today these carbides of titanium, tungsten, and tantalum, held together with a cobalt binder, are high-speed cutting tools. He said that carbide-tipped cutting tools are used in lathes, milling machines, boring machines, and drills, but that their use on a planer is not as common as on other machines, because planers generally do not run fast enough to warrant their use.

Dr. Lionel S. Marks Speaks at Utah Section

On Jan. 15 at Kingsbury Hall, University of Utah, Salt Lake City, Utah, Dr. Lionel S. Marks, Fellow A.S.M.E., professor emeritus of mechanical engineering, Harvard University, spoke on "Recent Developments in Jet Propulsion and Rockets." The meeting was under the joint sponsorship of the extension division of the University and the Utah Sec-

tion A.S.M.E. Dr. Marks delivered this lecture in the spring of 1945 throughout the East, and his visit in Salt Lake City was the first stop in a tour he is making through the Western and Southern states. An open forum was held at the conclusion of the lecture.

Monthly Forum Inaugurated at Ithaca Section

On Jan. 23 at the Arlington Hotel, Binghamton, N. Y., a monthly forum was inaugurated as a service to the Binghamton area members who cannot enjoy the usual type of meetings because of the wide territory covered by the Section. At this first meeting the speaker was Dean R. L. Sackett, fellow A.S.M.E., assistant to the secretary, A.S.M.E., who gave an inspiring informal talk on the advantages of membership and services offered by the Society.

"The Gas Turbine" Subject at Milwaukee Section

An interesting dinner meeting was held on Dec. 12, 1945, at the City Club, Milwaukee, Wis. Following dinner, Harris B. Tuttle of the sales service division, Eastman Kodak Company, Rochester, N. Y., spoke on "Photography in the War." A guest of honor was Thomas S. McEwan, regional vice-president, A.S.M.E.

At the regular meeting on Jan. 16, held in the Public Service Building Auditorium, Milwaukee, Wis., J. R. Carlson, member A.S.M.E., turbine engineer, South Philadelphia Works, Westinghouse Electric Corporation, spoke on "The Gas Turbine in Aviation and Industry." After Mr. Carlson's interesting talk the audience inspected the full-size cutaway model of Type 19B jet-propulsion engine which was on display in the auditorium. This engine was designed and built by Westinghouse for the Bureau of Aeronautics, U. S. Navy. It is 19 in. diam, 9 ft long, and weighs approximately 800 lb.

Ontario Section Hears About Heat Exchangers

A meeting was held at Hart House, University of Toronto, Toronto, Ontario, Can., on Jan. 10. The speaker was Bartholomew de Lorenzo. Mr. de Lorenzo, whose talk was on "Sectional-Type Heat Exchangers," discussed the advantages of small standard sectional-type heat exchangers over the conventional shell and tube-bundle-type exchangers. He also explained the advantages of extended surfaces on tubes and enumerated the various types of exchangers. Forty five were present.

"Transportation of the Future" Topic at Philadelphia Section

On Jan. 22 at the Engineers' Club, Philadelphia, Pa., Otto Kuhler, design consultant, spoke on "Transportation of the Future." Mr. Kuhler gave an excellent review of the evolution of streamlining as applied to railroad equipment and discussed the possibilities for future development of rail equipment from the standpoint of passenger comfort and convenience. The interest of the presentation was enhanced by accompanying colored slides and moving pictures. These covered some well-known streamlined trains, such as the *Royal Blue* and the *Hiawatha*, and also some of the improvements now being developed, such as improved coach lighting, means for converting sleeper washrooms into attractive smoking rooms, and improvements in club cars and observation cars.

The Philadelphia Section met the problem of the professional divisions by inaugurating a series of special-interest meetings for the period between Jan. 30 and May 14. These meetings will supplement the regular monthly meetings and will be devoted to the particular problems of the professional groups.

"Materials Handling" was the subject of the first special-interest meeting held on Jan. 30. Edward F. Mullin, retired chief engineer, Link-Belt Company, spoke on "The History and Development of Materials-Handling Equipment." Beginning with the Archimedean screw, he traced the evolution of the art of handling materials down to the modern practice of unloading grain cars in the matter of minutes by overturning the car and literally shaking out the grain.

M. C. Randall, Philadelphia Electric Company, contributed a paper, "Unusual Features of the Coal Handling Systems at the Southwark Station of the Philadelphia Electric Company."

Plainfield Section Has Air Transportation Program

Chester Hammond, Pan American World Airways, was the speaker at the Jan. 16 meeting at the Elks' Club, Elizabeth, N. J. In his talk entitled "International Air Transportation," Mr. Hammond said that our country's continued leadership in world air commerce is the cornerstone of our national security. This leadership can be maintained only if we safeguard the sovereignty over our air space, and have all American transportation companies—land, air, and sea—unite their efforts in operating one all-American international air-transportation company. Ninety seven were present.

Rock River Valley Section Enjoys Talk on Paper-Making Industry

On Jan. 25 a meeting was held at the Hilton Hotel, Beloit, Wis., with a dinner preceding. The speaker was P. H. Tigwell, sales engineer, Beloit Iron Works, whose subject was "High Lights of the Paper-Making Industry." Mr. Tigwell spoke for about 40 minutes, giving a brief history of paper making, general aspects, size, and importance of the paper industry in this country. He told of the raw materials used, their sources, the manufacture and uses of paper. He also told of the different types of paper-making machines, engineering features, and some of the problems involved in these machines. His talk was supplemented with slides. Then followed an excellent, well-edited sound motion picture entitled "Paper Making in the South." There were 70 present.

Joint Meeting of Rochester Section and Rochester Branch

A joint meeting was held with the Rochester Student Branch on Dec. 11, 1945, in the Lower Strong Auditorium at the Men's College on the River Campus, Rochester, N. Y. The occasion was the recognition and installation of officers of the Student Branch by the Rochester Section, represented by Stanley C. Stacy, chairman of the Committee on Student Branch and Junior Activities. The program consisted of talks on the "Rochester War Research Committee."

One talk was given by Geo. J. Lawrence, secretary of the committee, who spoke in place of Ray M. Biehler, chairman of the committee, who was unable to be present because of a severe hand injury. Mr. Lawrence explained how the committee was organized and operated. Dr. H. Lea Mason, a member of the committee and the new vice-chairman of the Section, gave a very interesting talk, illustrated with slides. He showed about 30 of the ingenious mechanisms developed during the war. These consisted of fuses, hand grenades, parachute release mechanisms, and smoke generators.

The Dec. 13 meeting was a great success with the attendance totaling 79. Everett S. Lee, engineer, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y., spoke on "What Is New in Science and Engineering."

Urban Transportation Discussed at St. Louis Section

On Dec. 14 Claude M. Gray, vice-president and operating manager of the St. Louis Public Service Company, St. Louis, Mo., gave a talk on "Urban Transportation Vehicles." The 60 members who attended had a very informative and interesting evening.

Precision Screw Threads Subject at Worcester Section

Ernest V. Flanders, Jones and Lamson Company, Springfield, Vt., was the speaker at the meeting on Jan. 10 held in the Worcester Polytechnic Institute, Worcester, Mass. In discussing his subject, "Modern Developments in the Manufacturing of Precision Screw Threads," he gave a history of screw threads, as far back as World War I. He told of four ways of making threads: Die-heads, thread rolling, thread milling, and grinding of threads. Mr. Flanders explained the gradual development in screw-thread manufacturing methods until World War II brought a great demand. During the war years new machines were developed for grinding screw threads, particularly for airplane work. Accompanying the talk was an excellent educational film

showing auto thread grinders. A total of 85 were in the audience.

Two Speakers Discuss Stratocruiser at West Washington Section

On Dec. 19, 1945, the prewar custom of having a Christmas party was resumed, and a party was held at the Faculty Club on the campus. Sixty six were present, half students and half members of the Section. The students were in charge of the program. Earl Beck gave a talk on his experiences in the Navy when the *California* was sunk and raised at Pearl Harbor. Ellis Sharkey talked on the V-12 program during the War. Both talks were excellent. A student "hill-billy" orchestra won its share of applause. Another interesting feature was a review by several engineers, members of the Section, of their engineering activities since their graduation.

A joint meeting with the Institute of Aeronautical Sciences was held on Jan. 8 in the Chamber of Commerce, Seattle, Wash. The speakers, A. F. Kelsey and R. L. Linforth, discussed the design features and air conditioning of the new "Tomorrow's Airplane Today"—the new Boeing stratocruiser.

Southern California Section Hears All About "The Power Package"

The Aviation Division of the section held a dinner meeting at the Clark Hotel, Los Angeles, Calif., on Jan. 9. Ray Roshong, chairman, introduced Comdr. Clay T. Colley, now on terminal leave from the Navy, who resumes his position as the section's membership committee chairman.

The topic of the evening was "The Power Package," and the speaker, Jack Zillman, engineering service representative, Adel Precision Products Corporation. Mr. Zillman outlined the challenge the aviation industry now faces in producing a good airplane within private incomes. To manufacture this type of plane, Mr. Zillman said, there must be simplified, compact, and standardized hydraulic system. "The Power Package," a complete eleven-unit 5-lb hydraulic system, meets these requirements and also meets the cyclic and low-temperature tests of the Army Air Forces. The only external connections are the electrical leads and actuating cylinder lines.

Virginia Section Has Unusual War Travel Program

On Jan. 10 in the Coca-Cola Building, Newport News, Va., A. K. Hutton and Mark L. Ireland, Jr., member A.S.M.E., gave a talk on their experiences in traveling and billeting with American and British troops. They illustrated their talk with slides of destroyed cities and plants. Slides showing German boiler designs were included. They said that German engineers were willing to give information and in some cases volunteered it. One hundred members and guests attended.

Student Branches

University of Akron Branch

The first official meeting of the season was held on Jan. 4 at Simmons Hall, when election of officers took place, with the following results: Anthony J. Fister, chairman; Robert O. Foster, vice-chairman; Daniel W. Hare, secretary-treasurer. The chairman appointed a program committee of two members, John Luber and James E. Masters, and a publicity committee, Andrew W. Slezak, chairman.

OFFICERS, 1945-1946, A.S.M.E. STUDENT BRANCH, QUEEN'S UNIVERSITY, KINGSTON, ONTARIO, CANADA

(*Left to right:* Gordon Johnson, treasurer; John W. Soden, president; E. J. C. Schmidlin, honorary president; Austin B. Hopkins, secretary; Tom Oosterhoff, vice-president.)

University of British Columbia Branch

On Nov. 1, 1945, two student papers were presented. Les Galloway spoke on the use of optical flats for precision measurements and Tom Buckam gave a paper on the principles of optics applied to photography. The Nov. 15 meeting was opened by Professor Vernon who gave an interesting talk on the field of opportunity for students. He pointed out that those contemplating going to the United States should see that they were first-class students first, and then they should secure a degree from an American university and be prepared to become American citizens. The next speaker was Professor Richmond. He felt Canadian students should feel morally obliged to stay in Canada and use their training to help develop the country. He added, however, that the most important thing for the student to do was to acquire first-class experience, and that might necessitate his apprenticing himself to a foreign office. A lively discussion followed these talks.

College of the City of New York Branch

The Nov. 30, 1945, meeting presented H. E. Linsley, editor of *Iron Age*. Mr. Linsley's subject was "The Production of the Wright Cyclone Engine," and as he was intimately associated with the development of the latest line of Wright Cyclone engines, he was able to present many interesting side lights on the development of this engine. His talk was accompanied by a sound film which stressed the change-over of the production methods due to the demands of war, and the need for hundreds of thousands of these power plants.

The speaker at the Dec. 6 meeting was James H. Wyld, consulting engineer, Reaction Motors, Inc., and president of the American Rocket Society, who spoke on "Rockets and Jet Propulsion." Mr. Wyld was associated with Dr. Goddard, one of the pioneers in the field of rockets. To illustrate his talk Mr. Wyld had some interesting slides showing the growth of rockets from the 2-lb gadgets launched 15 years ago, to the 200-ft-long V-2. An interesting and instructive question period followed the talk.

A meeting was held on Dec. 20 with the A.I.E.E., when Mr. Wellin of Allis-Chalmers Corporation spoke on "Steam Turbines and Condensers." He illustrated his talk with two films on these subjects, which were used by the Navy and Maritime Service during the war, for instructional purposes. During the question period Mr. Wellin pointed out the limitations upon the design of large machinery, such as critical speeds, vibrations, and high-temperature stresses.

Clarkson College Branch

On Jan. 24 a meeting was held in the auditorium of the main building when a film entitled "The Power Within," was shown. The program was under the direction of Prof. H. A. Weiss. The president, Jack Kelsey, gave a short talk on the importance of membership in the A.S.M.E.

Columbia University Branch

A meeting was held on Jan. 9 in the Pupin Building, when Dr. Steinman, bridge consultant, gave a talk on bridges and aerodynamics, using both films and models to illus-

trate his lecture. Of particular interest was the Tacoma Bridge failure. This meeting was held jointly with the A.I.E.E. student branch.

A business meeting was held on Jan. 23 in Pupin Physics Laboratories, to elect officers for the coming semester. Those elected were: Joe L. Berryman, president; Duane R. Chicoine, vice-president, John A. Tillinghast, secretary, and Edward F. Fanning, Jr., treasurer.

University of Idaho Branch

On Jan. 7 a meeting was held in Kirtley Laboratory when Messrs. Murry and Ollinger, representatives of The Hartford Boiler Insurance Company, gave a lecture with slides, on "The Causes of Boiler Failure."

A field trip was made to Spokane, Wash., on Jan. 17 for the purpose of attending a lecture on "Jet Propulsion and Rockets," by Dr. Lionel S. Marks, Fellow A.S.M.E., professor emeritus, Harvard University. Dr. Marks presented the true facts about jet propulsion and its apparent future.

Illinois Institute of Technology Branch

The first meeting of the new term was held on Jan. 11 in Room 305, Main Building. Tom Blin, president, presided and introduced Professor Budenholzer, honorary chairman. Professor Budenholzer told of the various awards presented to members competing in the various national contests of the A.S.M.E.

A film entitled "Steel, Man's Servant," was shown. This film depicted the entire story of the production of steel and its products from the mine through various phases of processing and forming to the final finished product.

Iowa State College Branch

At the meeting on Dec. 6 in Engineering Hall a film entitled "Abrasives" by the Carborundum Company and Bureau of Mines, showed the processing and uses of different types of grinding, cutting, and polishing wheels. Several Navy V-12 members were present.

University of Michigan Branch

New officers were elected at the Dec. 28, 1945, meeting, as follows: Richard J. Broadman, president, David Van Tuyl, vice-president, and Virginia Stuckey, secretary-treasurer.

On Jan. 24 a meeting was held in Michigan Union, when the new president, Richard J. Broadman, welcomed all regular and prospective members and announced the current membership drive. After the business meeting was over Prof. Frank L. Schwartz, adviser to the branch, gave an interesting illustrated talk on "Mathemagic," which dealt with useful mathematical tricks and shortcuts not usually encountered by a student.

University of Nebraska Branch

On Jan. 16 a meeting was held in Richards Laboratory, during which plans for a forthcoming freshman and returned-veteran smoker, to be held in the foundry, were approved, the purpose of which is to interest freshmen and encourage them to become mechanical engineers. Irwin L. Reis explained the coming regional convention. Honorary chairman N. H. Barnard presented an invitation from J. W. Kurtz to a stag party in Omaha. The program consisted of a paper on European railroads by Irwin C. Cone.

Northeastern University Branch

The first meeting of the new year was held on Jan. 3. Plans for coming programs were discussed. A film "Unsung Heroes," showing scenes in the testing department of one of the major refrigerator manufacturers in this country, was the feature.

Another meeting was held on Jan. 29 when a film entitled "Plastic Horizons" was shown. This film was shown through the courtesy of the Bakelite Company of America.

On Jan. 25 the branch sponsored its annual dance entitled "Flywheel Frolics." Machines were moved into the mechanical laboratory and dancing to records was the feature of the evening. Entertainment was provided by Bill Davidson, Lois Brady, and Professor Whittaker, formerly of the faculty, and now a member of the faculty of Massachusetts Institute of Technology, Cambridge, Mass.

Ohio State University Branch

At the Jan. 15 meeting an interesting talk was given by Ray C. Blaylock, chief engineer, Curtiss-Wright plant in Columbus, Ohio. His subject, "New Developments in Aviation," disclosed some amazing possibilities for the future of air travel. Mr. Blaylock described the various known methods for powering aircraft and their limitations.

Queen's University Branch

On Feb. 2 a tour was made through the plant of the nylon division, Canadian Industries Limited, Kingston, Ont., Can. This is the only plant of its kind in Canada, where the nylon polymer in flake form is manufactured into nylon yarn, ready for shipment to knitting mills. A large expansion program is under way at this plant and several new buildings are under construction. The trip was interesting and was thoroughly enjoyed by the students.

Rensselaer Polytechnic Institute Branch

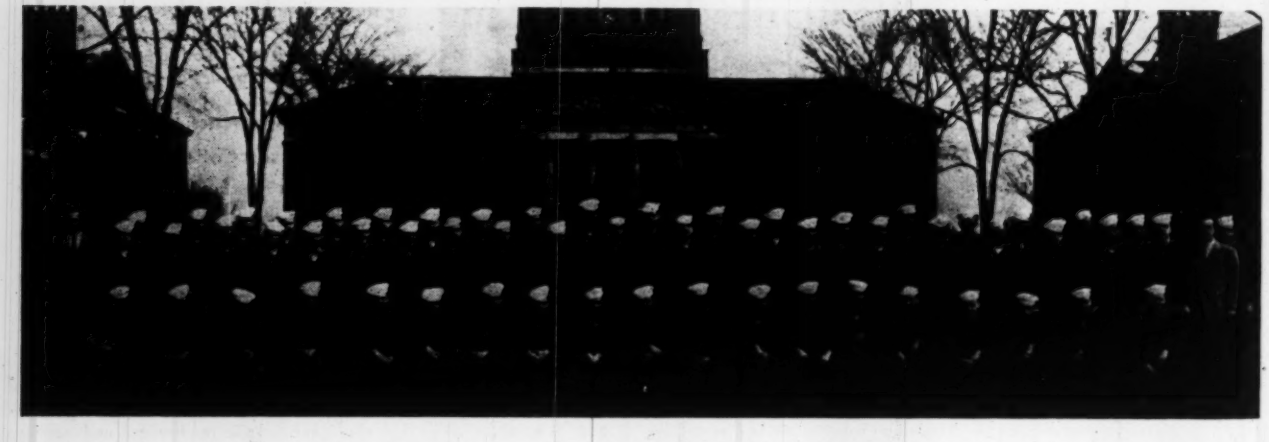
The first meeting of the new year was held on Jan. 10 in the Russell Sage Building, when Otto de Lorenzi, member A.S.M.E., director of education, Combustion Engineering Company, Inc., was the guest speaker. He spoke briefly on stoker fuel beds, using slides to illustrate, and then showed some "speed-up" and "slow-down" movies in color of the actual burning in the combustion spaces of several of his company's stoker boilers. He discussed the photographic problems inherent in the taking of these films, where the object is relatively inaccessible, and the intensity of illumination extremely high.

After the lecture plans for a membership drive and a departmental dinner were discussed.

University of Rochester Branch

The business meeting on Jan. 8 in the Rush Rhees Library was called to order by the chairman, Jack Krosse. The treasurer, Robert Hughes, reported that a profit of over $90 was made on the dance held on Dec. 8, 1945. Two films were presented, "The Evolution of the Oil Industry," and "The Wealth of the Andes," both of which were educational and entertaining.

Another meeting was held on Jan. 22, when two student members, William Harison and John McKeehan, presented papers. The first paper by William Harison, described German communications installations which he had



UNIVERSITY OF ROCHESTER A.S.M.E. STUDENT BRANCH

seen while in service with the Army. These were elaborately equipped to meet communication needs in case of bombings. The positions were located in outlying districts from large German cities where there was little danger of detection and bombings. He described how splicing problems were overcome when it was necessary to join a piece of copper wire to an aluminum wire.

John McKeehan explained how the electrical, mechanical, civil, and chemical engineers aided in the development of the motion picture. He described problems which were encountered and methods that were devised for their solution. The members approved a motion to award both speakers with an engineering handbook since the decision reached by the judges indicated that each speaker did equally well.

South Dakota State College Branch

A special meeting was held on Dec. 13, 1945, in the Engineers Building, to reorganize the Branch. The following officers were elected, Robert Nelsen, chairman; Glen S. Cherney, vice-chairman; John C. McWayne, secretary-treasurer; Prof. Lee L. Amidon, member A.S.M.E., honorary chairman. Seven students made application for membership.

University of Tennessee Branch

The meeting on Jan. 17 was opened by George Williams, president of the last quarter. Election of officers then followed. Those elected were: Bob Grass, chairman; Jim Slagle, vice-chairman; Mary Porter Fain, secretary-treasurer. A group discussion was then held on the aims of the branch and the type of programs desired. Messrs. Slagle and Bohanan were appointed as a program committee. Prof. F. H. Thomas, member A.S.M.E., honorary chairman, gave a brief discussion of the importance of the A.S.M.E. in student affairs. He urged that the branch be represented in attendance and presentation of papers at the A.S.M.E. Spring Meeting to be held in Chattanooga, Tenn. Three new members joined at this meeting, Sherman Hixon, Robert Sadley, and L. V. Eberle, Jr.

After a short business meeting, the program on Jan. 24 was turned over to Jim Slagle, program chairman. The speaker of the evening, Mr. Smetherman, was introduced. He gave a talk, with slides, on the history and processing of carbides and carbide tools. He had with him an interesting collection of carbide tools for inspection. A lively discussion period followed.

University of Toronto Branch

A joint meeting of junior members and the student branch was held on Dec. 6, 1945, in Hart House to give those present a clear picture of what is being done to better the wage standards of engineers, to point out the opportunities in engineering, and to answer questions troubling the young engineers today. Copies of the Engineers' Salary Survey, conducted and compiled by the Junior Engineering Institute of Canada, were distributed free to all present. The guest speakers who formed a panel of four included Dr. G. R. Lord, vice-president, Association of Professional Engineers, Province of Ontario; Brigadier Smythe, director, Technical Service Council; Tom Denbie, Federation of Employee Professional Engineers and Assistants; and A. L. Winfield, Salary Survey Committee, Junior Engineering Institute of Canada. The meeting proved very interesting and helpful to all.

On Dec. 10 a joint dinner meeting with the Mechanical Club of the faculty was held in the Great Hall of Hart House. The after-dinner address took place in the Debates Room. The guest speaker was W. F. Taylor, plastics division, Duplate Canada, Limited. Mr. Taylor discussed the types of plastics used and the principal methods of molding and extruding. To illustrate the design problems encountered in molding various articles, Mr. Taylor showed several examples of plastic products produced by his company. A discussion period followed his talk.

George Washington University Branch

The first meeting of 1946 was held on Jan. 2 in the Hall of Government. The program consisted of 15-minute talks by four student members. After his talk, each speaker was allowed a 5-minute question and answer period. The prize was a watch-and-key chain with a GWU insignia, and was won by Bob Manville for his talk on "The Effect of Supercharging and Increasing Compression Ratios on a Ford V-8." The other speakers were: Rudolph Gareau, "Wire Strain Gages;" Dave Johnson, "Automotive Carburetors;" and Frank Weathersbee, "Pyrometers." The judges were: Dr. A. F. Johnson, member A.S.M.E., honorary chairman; Prof. B. C. Cruickshanks, member A.S.M.E.; and Prof. R. G. Trumbull. Everyone enjoyed the program and it was decided to devote another regular meeting to talks by students.

University of Wisconsin Branch

On Dec. 15, 1945, in Memorial Union, the speaker was Pat Norris of the Home Insulation Company, Madison, Wis., who spoke on "Insulation, Sound and Otherwise." Mr. Norris discussed sound insulation, defined sound, and explained how it could be measured, the reasons for insulation and the types of insulation.

The Jan. 15 meeting was held in the Top Flight Room, Memorial Union, and called to order by George Hlavka, president. The program was a talk by James F. Roberts, member A.S.M.E., manager, hydraulic division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., entitled "Recent Developments in Modern Hydraulic Power Plants." Mr. Roberts explained the three types of hydraulic turbines, the impulse, the reaction, and the propeller types. He showed slides and discussed the construction operation and installation of the turbines at various plants.

Among the visitors were Mr. Coles, chief engineer, Madison-Kipp Company; Mr. Lapley, Madison division, Allis-Chalmers Manufacturing Company; Mr. Schudt, student chairman, Milwaukee section S.A.E.; E. L. Dahlund, member A.S.M.E., chairman of the Rock River Valley Section; and R. C. Glazebrook, member A.S.M.E., Mr. Lindau, and A. C. Dodge, associate A.S.M.E., all of the hydraulic division, Allis-Chalmers Manufacturing Company.

A.S.M.E. Sections

Coming Meetings

Akron-Canton. March 21. Place of meeting to be announced. Dinner at 6:30 p.m.; meeting at 8:00 p.m. Subject: "Tools for an Engineering Revolution, Strain Gages, etc.," by Francis G. Tatnall, Baldwin Locomotive Works, Philadelphia, Pa.

Baltimore. March 25. Engineer's Club of Baltimore at 8:00 p.m. Subject: "Air Transportation Today, A Glimpse of Tomorrow," by Charles Froesch, chief engineer, Eastern Airlines, New York, N. Y.

Central Illinois. March 14. Time and place of meeting to be announced. Subject: "Air Conditioning and Reverse Cycle Heating," by L. Gale Huggins, manager air conditioning, B. F. Sturtevant Company, Hyde Park, Boston, Mass.

Chicago. March 8. Reception at the Milwaukee Athletic Club. This is a joint meeting of the Milwaukee and Chicago Sections, A.S.M.E. Dr. Henry T. Heald, president, Illinois Institute of Technology, will address the Section on "The Service of Educational Institutions to Industry."

March 20, 21, 22. Chicago Production Conference.

Cincinnati. March 1. Wilson Auditorium, University of Cincinnati Campus at 8:00 p.m. Eleventh Annual Joint Meeting Technical and Scientific Societies Council of Cincinnati. Subject: "Science Shapes the Future," by Dr. Arthur H. Compton, chancellor, Washington University, St. Louis, Mo.

Columbus. March 22. Battelle Memorial Institute at 8:00 p.m. Subject: "Modern Trends in Stress Analysis," by Prof. S. M. Marco, associate professor of mechanical engineering, The Ohio State University, Columbus, Ohio.

Detroit. March 5. Horace H. Rackham Educational Memorial, 100 Farnsworth Ave., Detroit, Mich. Subject: "Rehabilitation of Europe's Power Systems," by Col. Walker Cisler, General Eisenhower's Staff.

East Tennessee. March 12. Municipal Court Room, Chattanooga, Tenn. at 8:00 p.m. Sponsored by the A.S.M.E. Section, the Chattanooga Subsections of the A.S.C.E. and A.I.E.E., and the Chattanooga Engineers' Club. Subject: "Jet Propulsion and Rockets," by Dr. Lionel S. Marks, professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass.

Fort Wayne. March 28. Dr. Lillian M. Gilbreth will address the Section members on "The Engineer's Part in Solving Today's Management Problems."

Hartford. March 5. Dinner at 7:00 p.m.; meeting at 8:00 p.m., at the City Club of Hartford, 10 Allyn St., Hartford, Conn. Subject: "The Engineer's Part in Solving Today's Management Problems," by Dr. Lillian M. Gilbreth, consulting management engineer, Montclair, N. J.

Metropolitan Section

March 5. 7:30 p.m., Room 503.[1] Photographic Group. "Technical Difficulties Encountered in the Development of Mass Production Color Print Service."

March 6. 6:00 p.m. and 7:45 p.m. New Jersey Division. Essex House, Newark, N. J. Dinner at 6:00 p.m.; meeting at 7:45 p.m. "Chemical Cleaning of Boilers and Heat Exchangers."

March 7. 7:30 p.m., Room 1105.[1] Engineers' Forum. "New Technical Developments and Their Effects on Our Future."

March 7. 8:00 p.m., Room 502.[1] Materials Handling Division. "Modern Trends in the Design and Application of Materials-Handling Equipment and Methods."

March 8. 7:30 p.m., Room 503.[1] Machine Shop Division. "Precision Casting and Its Postwar Possibilities."

March 14. 12:30 p.m., Engineering Woman's Club. Woman's Auxiliary Annual Card Party Benefit. Calvin W. Rice Memorial Scholarship Fund.

March 18. 7:30 p.m. Room 1101.[1] First meeting, Materials-Handling Forum.

March 19. 6:30 p.m. and 7:30 p.m., Childs Restaurant, 109 West 42nd St., New York, N. Y., Junior Group. "Medical Applications of Mechanical Engineering."

March 26. 7:30 p.m., Room 502.[1] Transportation Division. "Aspects of Rail and Air Transportation."

March 26. 8:00 p.m. New Jersey Division. Auditorium Central High School, Newark, N. J., "Northern New Jersey Transportation."

March 27. 7:30 p.m., Auditorium.[1] Heat Transfer Division. "Heat Transfer in Modern Chemical Dehumidification."

March 28. 7:30 p.m., Room 503.[1] Industrial Instruments and Regulators Division. "Typical Example of Controls."

March 28. 7:30 p.m., Room 1105.[1] Engineers Forum. "Political Campaign Speeches."

Mid-Continent. March 28. Room 101, Engineering Building, Tulsa University, Tulsa, Okla. at 8:00 p.m. Subject: "Fatigue and Corrosion Fatigue of Steels," by Blaine B. Wescott, Gulf Oil Corporation, Pittsburgh, Pa.

Milwaukee. March 8. Plankington Hotel, Sky Room, Milwaukee, Wis., at 8:00 p.m. This is a Joint Meeting with Chicago Section, A.S.M.E., preceded by an afternoon tour of the Pabst Brewery, Milwaukee, Wis. Subject: "The Service of Educational Institutions to Industry," by Henry T. Heald, president, Illinois Institute of Technology, Chicago, Ill.

Minnesota. March 12. Time and place of meeting to be announced. Subject: "The Engineer's Part in Solving Today's Management Problems," by Dr. Lillian M. Gilbreth, consulting management engineer, Montclair, N. J.

Nebraska. March 20. University of Nebraska, Lincoln, Neb. Subject: "Engineering as a Profession," by Glen C. Boyer, vice-president, Burns & McDonnell, Kansas City, Mo.

New Orleans. March 6. St. Charles Hotel at 8:00 p.m. Subject: "Jet Propulsion and Rockets," by Dr. Lionel S. Marks, professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass.

Ontario. March 14. Hart House, University of Toronto, Toronto, Ontario, Can.; dinner at 6:15 p.m.; meeting at 7:30 p.m. Subject: "Air-craft Gas Turbines," by Winnett Boyd, chief of engine design section, Turbo Research, Limited, Leaside, Ontario, Can.

Philadelphia. March 26. Philadelphia Engineers' Club, 1317 Spruce St., Philadelphia, Pa. Subject: "What Engineers Can Learn From the Enemy," by D. B. Keyes, director, Office of Scientific Research and Development.

Piedmont-North Carolina. March 19. Efirds Dining Room at 6:30 p.m.; meeting at 7:30 p.m. Subject: "Jet Propulsion and Rockets," by Dr. Lionel S. Marks, professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass.

Plainfield. March 20. Masonic Hall, Westfield, N. J. at 8:15 p.m. Subject: "Fluid Catalytic Cracking," by O. L. White, general engineering department, Standard Oil Development Company; and Ernest Hartford, executive assistant secretary, The American Society of Mechanical Engineers, will give a short address on "Society Functions and Advantages of Membership."

Southern California

March 14. Dinner at 6:30 p.m., Clark Hotel. Speakers: Art Wistler and C. M. Sandland, both of C. F. Braun Company. This meeting will be sponsored by the Heat Transfer and Petroleum Division.

March 28. Meeting sponsored by the Hydraulics Division. The speaker for this meeting will be from Kobe, Incorporated.

March 29. Field Trip—Hydraulic Division (limited to 75 members), Kobe, Incorporated, 3040 East Slauson at 1:00 p.m.

South Texas. March 1. Physics Lecture Hall, Rice Institute, Houston, Tex., at 8:00 p.m. Subject: "Jet Propulsion and Rockets," by Dr. Lionel S. Marks, professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass.

West Virginia. March 26. Daniel Boone Hotel, Charleston, W. Va., at 7:45 p.m. Subject: "Light Planes and Airports," by W. T. Piper, Piper Aircraft Corporation, Lock Haven, Pa.

Worcester. March 4. Putnam and Thurston Restaurant, 27 Mechanic St., Worcester, Mass., dinner at 6:30 p.m.; meeting at 8:00 p.m. Subject: "The Engineer's Part in Solving Today's Management Problems," by Dr. Lillian M. Gilbreth, consulting management engineer, Montclair, N. J.

[1] Engineering Societies Building, 29 West 39th St., New York, N. Y.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	212 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

GRADUATE ENGINEER, MECHANICAL, 30, married. Three years' experience plant operation, construction, estimating, test procedures in transportation, and public utilities. Four years' Army Air Forces staff officer procurement, training, and office management. Me-9.

GRADUATE MECHANICAL ENGINEER, 30, recently released from Navy. Experienced in design, drafting, inspection, and quality control. Desires permanent position in production or quality-control department. Prefer Midwest. Me-10-2520-Chicago.

MANAGEMENT EXECUTIVE. Vice-president and general manager engineering company (doing war work) seeks new connection. Twenty years' experience as executive in engineering, production, general management. Specially qualified as organizer and getting production results Experienced major air-line executive. Married. Me-11.

GRADUATE MECHANICAL ENGINEER, 25, single, with background of machine-shop practice and one year industrial experience, desires foreign position in food, chemical, or process plant, preferably as assistant plant engineer. Me-12.

WELL-SEASONED YOUNG MECHANICAL ENGINEER, wants sales engineering or product de-

[1] All men listed hold some form of A.S.M.E. membership.

velopment work. War record includes responsible product development experience in Army Ordnance, followed by diplomatic assignment abroad as technical observer. Me-13.

GRADUATE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, marine engineer, 30. Nine years' shipyard experience testing, supervising, organizing. Desires position with manufacturer hydraulic or mechanical equipment. Me-14.

GRADUATE MECHANICAL ENGINEER, 29, married. Design and development experience at U. S. Arsenal, also Army technical experience. Desires permanent position with industrial concern in production organization or control. Eastern U. S. preferred. Me-15.

MECHANICAL ENGINEER, 32. Factory management, production control, cost analysis. Experienced precision manufacture small metal parts. Two years' naval officer, Diesel machinery experience. Four years executive management field. Location, secondary. Me-16.

ENGINEER with specialty of fire-protection engineering and insurance management. Many years' treasurer and manager Canadian branch plant making heavy machinery. Nearing 50, desires to locate in New England. Could handle fire-protection engineering large plant including insurance matters. Veteran of two wars. Me-17.

MECHANICAL ENGINEER, Ph.D., registered. Experienced metal-products production, testing and development, supervision machinery erection. Three years' steam-station operation, five years' heat-power instruction. Desires responsible development, manufacturing or power-plant position. North preferred. Me-18.

SALES ENGINEER, graduate M.E., age 25, married, veteran. Sales experience, industrial valves in Midwest. Wishes to locate in New York, N. Y. Me-19.

GRADUATE INDUSTRIAL ENGINEER, seven years' diversified experience in all phases management engineering. Especially qualified design, install, and co-ordinate systems of cost and production control. Recent consulting experience. Me-20.

POSITIONS AVAILABLE

ENGINEERS, mechanical or chemical. Several appointments open in development, application, and sales engineering departments for qualified engineers with power-plant or process-industry experience. Write stating experience, technical training, salary requirements. Illinois. W-6511.

CADET MECHANICAL ENGINEER for consulting engineering company, to design, operate, and maintain foreign steam-electric generating stations. Apply by letter giving age, education, experience, salary expected. New York, N. Y. W-6520.

ASSISTANT PLANT ENGINEER, make layout and detail drawings covering process and power-plant equipment, industrial construction, preparation of specifications, and some field supervision for general engineering department. Some traveling Midwest and East. $3600–$4200 year. Headquarters, New York, N. Y. W-6552.

PROFESSOR to take charge of mechanical engineering department. Will have some teaching duties, particularly heat and power. $6000–$7500 year. East. W-6562.

TECHNICAL AND SALES PROMOTION ENGINEER, first-class, for old established company producing important metals. Industrial and metallurgical engineering experience in China and other Oriental fields essential. Far East. W-6577.

JUNIOR AND SENIOR SALES ENGINEERS, 23–30, single, preferably mechanical graduates, with three to four years' experience around various kinds of machinery, although similar length of time spent in Army Ordnance would be considered. Actual sales experience not necessary but applicants must be sales-minded. Must speak Spanish. $3000–$5400 year. Caribbean Area. W-6583.

EXPERIMENTAL ENGINEER, electrical or mechanical graduate, with broad interests. Some experience in experimental stress analysis desirable but not essential if applicant has good technical background and can readily adapt himself to new work. Working knowledge of electronics desirable in connection with use and maintenance of test equipment. Must have initiative and be capable of carrying out work assigned with minimum of supervision. Write, stating experience, personal record, and expected salary. Metropolitan New Jersey. W-6591.

INSTRUCTOR OR PROFESSOR of mechanical engineering, 25–35, mechanical graduate, with some industrial experience, to teach courses in machine design, mechanical engineering laboratory, with perhaps ability to help out in steam power. Permanent. Salary open. Alabama. W-6597.

SUPERINTENDENT, 30–35, to be operating head of department in large plant in wire and cable field. Work will consist of co-ordinating of layout of plant and development manufacturing methods. About $4800 year. Northern New Jersey. W-6619.

ASSISTANT EDITOR, preferably with some experience in machinery design and one who has aptitude for editorial work. Excellent opportunity. Salary open. Ohio. W-6623.

CHIEF INDUSTRIAL ENGINEER, 35–45, industrial or administration engineering graduate, ten to fifteen years' experience, supervise general office staff and branch plants of processing and packing concern. Must have had similar experience as senior industrial engineer with manufacturer covering methods, job analysis, rate setting, wage incentive, cost analysis, cost reduction, and production control. $7500–$10,000 year. Pennsylvania. W-6625.

PRODUCTION MANAGER, mechanical engineer, for metal and plastic products. Must have had machine-shop experience, especially automatic screw machines, punch presses, etc. $8000 year. New York, N. Y. W-6633.

E[illegible]INEERS. (*a*) Methods Planners of tools, three to five years' experience, to plan tooling methods and sequence of operations of complex parts requiring numerous operations for high rate of production. Will work from blueprints and specifications; consider handling problems, economy of operations, quality, and finish. Advise on necessity of new machines or equipment. (*b*) Shop Contact Man, three to five years' experience, to consult with and advise shop on interpretation of operation sheets in relation to obtaining satisfactory production from existing tools and equipment. Provide solutions of such problems as relating to capacity, tools, methods, and holding devices. Connecticut. W-6659.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after March 25, 1946, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number or references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate, or Junior

ALDREY, JUAN L., Caracas, Venezuela
ALETTI, AMABILE E., Philadelphia, Pa.
ALLEN, FRANK L., JR. (LIEUT.), New York, N. Y.
ANDERSON, H. H. (LIEUT. COL.), Duncraig, Scotland
BAILLIE, WALLACE E., Chicago, Ill.
BARNARD, DANIEL P., 4th, Chicago, Ill.
BARNETT, ROGER M., Dixon, Ill.
BARTLETT, ELVIN E., Seattle, Wash.
BENDLER, ALBERT J., Staten Island, N. Y.
BITTERMANN, F. J., Wheaton, Ill.
BJARNASON, JOHANNES, Reykjavik, Iceland
BRECKENRIDGE, ROBERT M., Philadelphia, Pa.
BROWN, CLYDE E., Worcester, Mass.
BROWN, JOSEPH ARTHUR, Vallejo, Calif.
BURKMAN, C. HERBERT, McKeesport, Pa.
CHESLEY, J. O., Pittsburgh, Pa.
CLEMENT, A. J. F., Culver City, Calif.
CLEMMITT, WILLIS B., Chicago, Ill.
CLIPPERTON, JAMES E., Trinidad, B. W. I.
COOLEY, KENNETH D., Columbus, Ohio
CORNWELL, DONOVAN C., Philadelphia, Pa.
DARLING, LYMAN A., Wilmington, Del. (Rt & T)
DEVRIES, F. L., Sao Paulo, Brazil
DILWORTH, JOHN A., 3RD (CAPT.), Dayton, Ohio
DITTUS, FREDERICK W., New York, N. Y. (Rt & T)
DOELL, HARRY A., Santa Barbara, Calif.
DONWORTH, ROBERT B., Pittsburgh, Pa.
ELAHI, FAZAL S., Lahore, India
FAY, RICHARD A., Worcester, Mass. (Rt)
FEDELER, J. H. E., Ridgewood, N. J. (Rt)